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THE PARIS EXHIBITION—ELECTRICITY ON THE EIFFEL TOWER.

THE majority of persons who admire the colossal stature of the Eiffel tower, who are astonished at its height, at the mass of iron which has entered into its construction, and at the intellectual and material efforts which were necessary to the design and the realization of such a great and original scheme, confine their wonder to what stands before them, astonishing them by its height and its proportions. But there are very few, certainly, who have any idea of the number and the complexity of the auxiliary services which the great work has involved; it is true that all these are absorbed in the striking reality of the principal work, yet, nevertheless, the supplementary labors were attended with great difficulties, and reflect the highest honor on those engineers to whom they were intrusted. Among these auxiliary services that of the electric installations is certainly the most interesting, and in confiding it to MM. Sautter, Lemonnier & Co., M. Eiffel knew that he was placing the weighty responsibility in thoroughly reliable hands. From the following article our readers will be able to judge of the importance of the work carried out by this eminent firm.

The electric installations of the Eiffel tower may be separated into three distinct groups: 1. The great lighthouse which crowns the edifice. 2. The two projectors placed on the fourth platform. 3. The various lamps lighting different parts of the tower. We will take each of these three installations in its proper order.

1. *The Lighthouse of the Eiffel Tower.*—Lighthouse illumination is one of the branches of the great establishment of MM. Sautter, Lemonnier & Co.; the firm was, in fact, one of the first to undertake work of this class, for their house was founded in 1825 by the French optician Soleil for the construction of lenticular lighthouse apparatus, which Augustin Fresnel had then recently invented, and the greater number of lighthouses on this system which are now in use have been constructed by them; from the time their house was founded up to the present date they have completed no less than 2,061 such installations. It follows, therefore, almost as a matter of course, that they were intrusted with the construction of the great signal light for the Eiffel tower. The establishment of a beam of immense power at the extreme summit of the 300 meter column was obviously a necessity. It was impossible to imagine the immense structure making no visible sign of its existence in the darkness. Some people have irreverently compared the tower to a gigantic candlestick, and the comparison is not altogether without excuse; all the more reason was there, therefore, that the light should burn brilliantly at its summit. This light was not intended to be seen from the foot of the tower, and there is no cause for surprise at the comparative indifference with which the night visitors to the Champ de Mars regard it, absorbed as they are moreover by the effect of the luminous fountains and the beautiful illuminations in the grounds. The object of the designers of the light at the summit of the tower was to produce a beam visible from a distance of 1,500 meters from the axis of the structure, as far as the horizon, and of an intensity approximately equal at the varying distances at which the observers may be stationed.

To really appreciate the beauty of the light, we would advise visitors (speaking from personal experience) to go to the summit of the heights of Montmartre on a clear night. From the foot of the church of the Sacre Cœur, Paris is seen sparkling with a million lights, and to the right rises the gigantic tower, the beam from which streams across the sky like a splendid meteor. The spectacle is a striking one and well repays the visitor for the trouble and fatigue of climbing up the slopes and mounting the staircases of the Buttes. The electric light of the tower belongs to the category of ordinary lighthouse lights, with a dioptric drum 23·62 in. interior diameter, and of the type adopted by the French administration, only modified, as we shall presently see, in order to render the light visible 1,500 m. from the foot of the tower.

Fig. 1, which represents the summit of the edifice, indicates also the general arrangements and the space allotted to the installation; Fig. 2 shows the details of the optical system and of the lamp. The luminous center is in the axis of the principal ring; it was not considered advisable to extend the projector much beyond this, the continuous current giving the maximum of light at an angle of 40 deg. below the horizontal; the apparatus throws the light to the horizon, concentrating it within an angle of about 1·5 deg. Five catadioptric prisms extend the drum in its lower part, and it is here that the modification above referred to has been made; the object was to allow the beam to be seen at a distance of 1,500 meters from the foot of the tower, the prisms having been calculated in such a way as to project the light at an angle of about 12 deg. below the horizontal.

FIG. 3.—PROJECTOR EXHIBITED BY MESSRS. SAUTTER, LEMONNIER & CO.

This arrangement of prisms, of so great divergence, which was really necessary on account of the altitude of the light, has been employed here for the first time; indeed, it would be without any object for ordinary purposes, as maritime lighthouses throw the totality of their beams to the horizon. This great angle of dispersion of the rays involved the necessity of special calculation and fashioning for the five catadioptric prisms. The optical arrangement which we have described constitutes a fixed light, that is to say, a beam lighting equally over the whole circumference. The flashes are obtained by means of vertical plano-convex lenses, the full height of the apparatus, and which concentrate the light by increasing its intensity in the proportion of one to 7·68, that is to say, by making it eight times more powerful. The optical part of the installation is fixed on a revolving drum, which makes one complete turn in 90 seconds; the flashes have each of them a duration of 3 seconds, and their total period is equal to two-thirds of the time of one revolution. The movement of the drum is produced by a small electric motor placed above the apparatus, and which operates, by means of a pinion, a toothed wheel fixed on the movable drum. The small amount of energy required to drive the motor (half an ampere and 50 volts) is taken direct from the lamp circuit; only a small power is required for this work because the revolving portion turns on a steel spindle with very little friction, and variations in the movement of the drum can be effected by introducing resistances into the exciting circuit; we believe that this is the first time that an electric motor has been used for driving a lighthouse light. A number of lateral guide wheels are introduced to neutralize the effect of oscillations in the tower on the rotating movement.

The luminous intensity of this great beam is equal to about 55,000 candles; that is to say, its intensity is equal to that which would be produced by 5,500 carcel lamps. The amplifying power of the dioptric drum is thirteen, so that the intensity of the light projected toward the horizon is magnified thirteen times, and is therefore equal to about 700,000 candles. In the catadioptric rings the light is distributed unequally in such a way that the various portions receive a stronger and stronger light as the distance of the beam from the foot of the tower increases. It is in this way that the lower part of the first ring commences to throw a light at a distance of 1,500 meters, taking in the Pont de Grenelle, La Muette, the Avenue des Champs Elysees, the Esplanade des Invalides, etc., and gives during the flashes a brilliancy of 24,000 carcels; at 1,600 meters distant the intensity is 50,000 carcels, at 1,900 meters it is 64,000, at 2,200 meters it rises to 86,000, and at 4,100 meters to 99,000.

The range of light in clear weather should be 127 miles, with a maximum intensity of 500,000 carcels, but the curvature of the earth greatly limits the range. At a level of 330 meters above the sea, which is the height of the lantern of the tower, the geographical limit is only 70·2 kilometers; taking the effect of refraction into account, which flattens the rays, an observer placed at a height of 300 meters could see the beam at a maximum distance of 141·2 kilometers, of course assuming that there were no intermediate obstacles. From careful observations which have been made the Eiffel tower light is visible from the following places: Chartres, 75 kilometers; Fontainebleau, 60 kilometers; Beauvais, 66 kilometers; Orleans, 112 kilometers (from the top of the cathedral). One observation has been reported at Bar-sur-Aube, a distance of 190 kilometers, but this is clearly impossible on account of the hills surrounding the town; in any case it may be stated without fear of contradiction that the signal light of the Eiffel tower, on account of its position and its power, has a greater range than any other signal light in existence. The lamp employed is an electric regulator of a mixed type, either automatic or worked by hand, fed by a current of 100 amperes and 70 volts; this lamp is regulated from the lower part of the projector, three screwed rods controlled by a hand wheel and

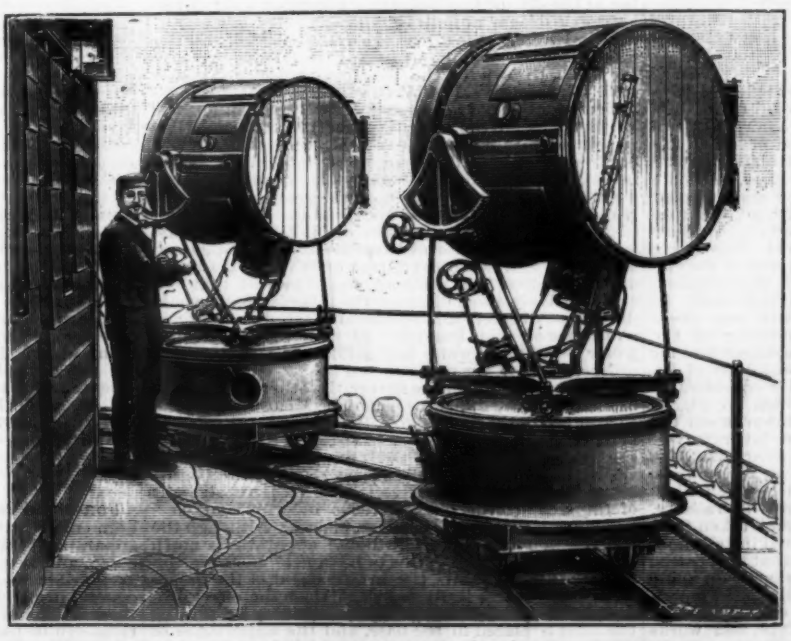
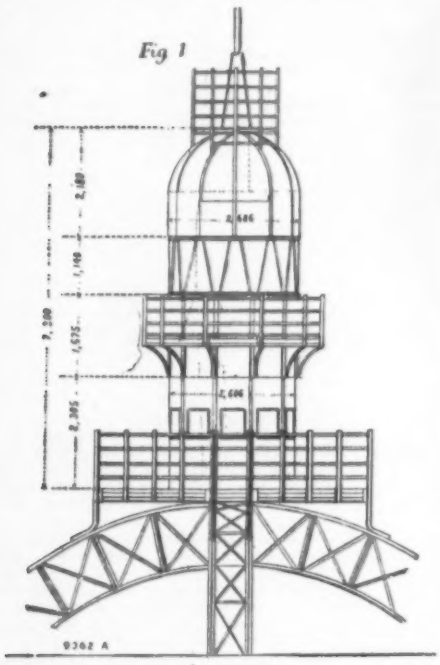


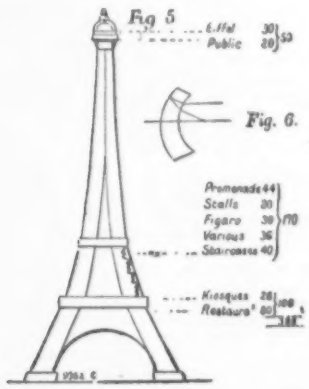
FIG. 4.—MANGIN PROJECTORS ON THE EIFFEL TOWER.

gearing allowing it to be raised or lowered. The adjustment of the voltaic arc is secured by a total reflection prismatic lens fixed to coincide with the optical axis of the drum. The image of the carbons is reflected on a screen conveniently arranged for the inspection of the person in charge of the apparatus. A mark on the screen makes it easy to bring the reflected image exactly to the desired point, that is to say to the axis of the reflector. The carbons burned in the lamp are 1·18 in. in diameter, and they last for six hours. The colored flashes are produced by two colored glass screens placed in front of the vertical lenses; they succeed each other in the following order: red flash, white flash, blue flash, fixed white beam, red flash, etc.

2. *Projectors.*—Two projectors placed on the Eiffel tower below the platform of the great signal supply the means by which the two long rays of electric light, now so familiar to every one in Paris, are thrown toward the horizon. These projectors are on the system devised by Colonel Mangin, who died about two years since. It may be of interest to refer briefly to the principles on which the working of this apparatus depends. The first projectors employed were parabolic mirrors, which, in a geometrical point of view, afforded a complete solution to the problem of making the ray from a luminous center parallel. Unfortunately practical difficulties stood in the way of the adoption of this complete and simple theory, the difficulties of producing, either in glass or in metal, surfaces of geometrical accuracy. The obstacles in fact were so great that the use of parabolic reflectors had to be abandoned, and this led Colonel Mangin, then a military

Fig 1





engineer, to endeavor to obtain parallel reflected rays by means of surfaces more easily obtained. Ultimately he produced the mirror which bears his name, with two spherical surfaces, exterior and interior, of which the degrees of curvature were carefully calculated, taking into account the index of refraction of glass, in such a way that the reflected and refracted rays are projected parallel to the axis of the mirror. Without entering into detail we may refer to the diagram, to show how the parallelism of the rays is obtained. This simple and ingenious solution gave a rapid impulse to the employment of projectors, and since 1878 their application to the art of war has become almost universal. In France, where the invention had its birth and where it was developed, MM. Sautter, Lemonnier & Co. have constructed for the fortress department and for the French navy a large number of projectors of different types; they have also supplied a considerable quantity to foreign nations. Those which are placed on the fourth platform of the Eiffel tower, upon the balcony that surrounds the office and laboratory of M. Eiffel, are of the 35·43 in. type, such as are made for French harbor defense. They are two in number, mounted on a base provided with wheels which allow them to travel rapidly on a small Decauville railway. Fig. 4, which is engraved from a photograph taken from the summit of the tower, shows the actual installation. A special feature in their construction is that they can be inclined so as to project the electric beam at an angle of 45 deg., to light up near objects, such as the monumental fountain, the central dome, etc. The lamp is of the mixed Sautter-Lemonnier type, and works with a normal current of 100 amperes. The divergence of the beam is obtained simply by shifting the luminous center of the lamp. Under favorable conditions of observation, and by means of a good night glass, it is possible to distinguish the details of objects lighted by the beam at a distance of four or five miles. All the puplic monuments of Paris are clearly visible, and the navigation on the Seine is quite brilliantly lighted up when the beam is turned upon the river; only a few nights ago the light was used to good advantage by enabling men to work in unloading a damaged barge that was threatening to sink and block the channel. The beam from these projectors turned upon the observatory of Meudon has enabled M. Janssen to make a series of interesting spectroscopic observations.

It is known that among the lines visible in the solar spectrum a certain number are peculiar to the solar atmosphere, while the presence of others can be traced to the atmosphere of our earth, but it is difficult to establish all the actual distinctions; one solution consists in taking observations at as great a height as it is possible to reach. It was in this direction that M. Janssen, in spite of his advanced age, made last year a number of remarkable experiments; he caused himself to be assisted up Mont Blanc under the shelter of the Grands Mulets, and from the experiments he made there, concluded that all the oxygen lines in the spectrum are due to the atmosphere. Now, he has calculated that the distance from the top of the Eiffel tower to the observatory at Meudon (7,200 meters) is approximately equal to the height of the terrestrial atmosphere if its density was constant. The number of molecules of air encountered by the beam thrown from the projector would, therefore, be about the same as that of the molecules encountered by a solar ray; the disturbing influence due to the terrestrial atmosphere should therefore be about the same in both cases. This is the principle of the experiments from which M. Janssen has deduced a striking confirmation of the theories which he had previously announced. It is satisfactory to see that an instrument which, like the Mangin projector, is devoted almost wholly to military purposes, can be converted in the hands of a physicist into a pacific weapon, a willing servant to scientific inquiry.

If for a moment the reader will permit us to turn our back upon the Eiffel tower, and to which we will return directly, we will ask him to admire with us, in the central exhibit of Messrs. Sautter, Lemonnier & Co., and placed in the middle of the Machinery Hall, an enormous projector 56 in. in diameter, and of which one can say that it is the Eiffel tower among all other constructions of a similar kind. Hitherto, indeed, the largest projector of this type which has been made has been less than 24 in. in diameter. Such an increase in size is attended with difficulties almost impossible to overestimate, especially those connected with the construction of the mirror, for the problem was not to make a spherical mirror, but one that should be aplanatic, in which the aberration due to sphericity should be wholly avoided.

All the parallel rays of light reflecting on this large surface converge almost in a mathematical point, which is not more than one millimeter in diameter. The production of the glass was intrusted to the St. Gobain works, and it was only after many failures that the large block was obtained without air bubbles, cracks, or other faults. The cutting of the mirror, which was executed in the works of MM. Sautter, Lemonnier & Co., was found to be very difficult in the commencement, and it involved the necessity of a special and very perfectly arranged plant; no one who has not had the special experience can imagine how difficult it is to obtain surfaces mathematically exact and conforming absolutely to data obtained by calculation. The amplifying power of this great projector is enormous, being 5,625 for a lamp of 150 amperes, and giving from 10,000 to 11,000 carcels; the intensity of the beam projected from this lamp would be, therefore, from 50,000 to 60,000 of carcels, or from eight to ten times the intensity given by the projectors that are placed upon the tower. At a distance of 100 meters from the projector the intensity is equal to that of the sun, assuming the calculation to be correct that the solar energy is equal to that which would be given out by a lamp of 6,000 carcels upon a surface placed at one meter distance. The beam being equal to 60,000,000 of carcels at one meter of distance, at 100 meters away the whole area lighted by the beam would receive as much as the sun could give when shining with its full force. But it is impossible for the eye to judge the values of these great luminous intensities, and it is for this reason very difficult to compare the values of two beams thrown by the Mangin projectors. In looking at the side of the beam the spectator only distinguishes a stream of light of comparatively low intensity; in looking at it direct the eyes are blinded. For this reason we should not be surprised if the effect of the beam thrown by the monster projector does not fulfill apparently all that is expected of it. It is as difficult for the eye to appreciate such great intensities as it is to gauge the height of the Eiffel tower when remaining within the limits of the exhibition and trying to compare it with surrounding buildings. It will be only at great distances when the beam is thrown upon objects very far away that the great power of the Mangin projector can be appreciated. One element of great importance which the eye fails to appreciate is the optical perfection of the reflector. The spherical aberration of a spherical mirror of 56 in. in diameter, and of the same focal distance, would be such that at a comparatively short distance the reflected light would disappear, diffused and scattered in all directions; at a distance of some hundreds of meters from the projector it would be quite impossible to appreciate any difference whatever between two beams, one projected from an ordinary concave mirror, the other of an aplanatic mirror; the difficulty would be almost as great as to appreciate the depth of a limpid and transparent lake, of which the bottom was visible. Before leaving the principal exhibit of MM. Sautter, Lemonnier & Co. in the Machinery Hall, we may mention the lighthouse which crowns their collection; it is an oil light of the second order, in the focus of which an electric lamp of 60 amperes has been placed. Although the construction of electric lighthouse apparatus is much more difficult and requires to be much more precise than that for oil lights, the arrangement of the prisms in this apparatus is so excellent that the effect produced is very satisfactory. The machinery for turning the light is placed in the base, and the appearance of the illumination is that of a fixed light with white flashes.

3. *The Incandescence Lighting on the Tower.*—Besides the rows of gas lamps that at night line out the various platforms of the tower and the great arches beneath the first story, the restaurants and kiosks, the staircases, the offices and the printing establishment of the *Figaro*, the public promenades, and M. Eiffel's laboratory are lighted by 300 incandescence lamps, the arrangement of which is indicated in the sketch, Fig. 5.

4. *The Production of the Current.*—The small electric installation that furnishes the current to the lighthouse, the projectors, and the incandescence lamps is placed in the southern pier of the tower. A Piloy two-cylinder compound engine of 35 horse power nominal, but which works to 70 horse power, furnishes the power; it drives a very light six-pole dynamo of the so-called marine type, supplying 600 amperes at 80 volts and at a speed of 850 revolutions; the dynamo is driven by a belt. Six cables carried upon porcelain insulators lead the current to the upper platform, two being required for the lighthouse and two for each of the projectors; six other conductors serve for the incandescence lighting. The means employed for regulating the dynamo and the motor are practically perfect, and even when the current from the lighthouse and the projectors is shut off, the effect on the incandescence lamps is not appreciable. A second somewhat similar installation will soon be added to the one now in operation, rais-

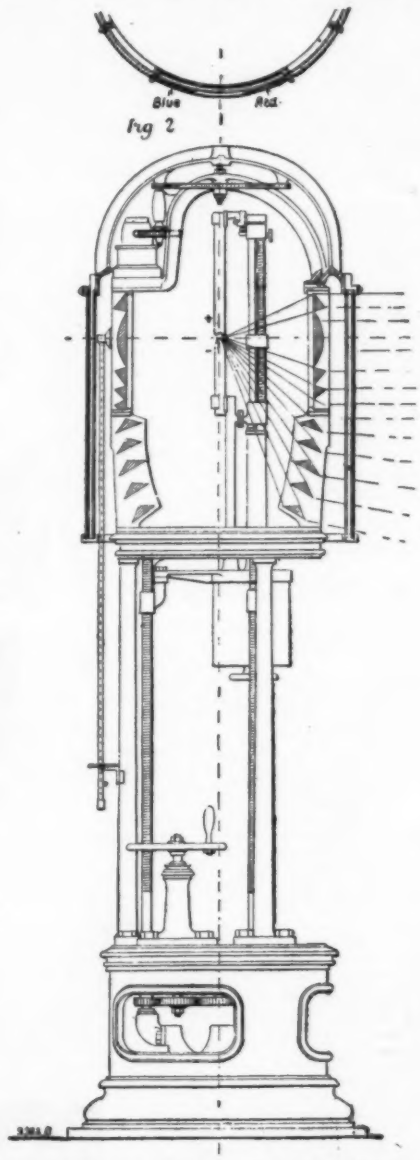


Fig 2

ing the total value of the current available for the tower to 1,200 amperes, or 130 electrical horse power. The whole of this installation reflects the greatest credit on MM. Sautter, Lemmonier & Co., and it should be remarked that they alone, of all the numerous subcontractors employed by M. Eiffel, were ready on the day that the exhibition was opened, and this in spite of the great difficulties connected with the lifting and erecting such delicate pieces as those of which the lighthouse and the projectors are composed. What added to the difficulty was that the erecting cranes having been removed, everything had to be carried up by hand. The result obtained is all the more remarkable since the order for the installation was only given out on February 20 last, while the other contracts had been settled eighteen months previously. Certainly the work would not have been so well and rapidly executed were it not for the admirable organization in the works of MM. Sautter, Lemonnier & Co.; but it would be superfluous to speak in praise of this famous establishment.—*Engineering.*

THE PHONOPORE.

FOR some years past Mr. C. Langdon-Davies has been engaged in elaborating a new form of telegragh apparatus, to which the name "phonopore" has been given, and we propose to explain as simply and shortly as possible what this instrument is, and what is the general principle of its action. It is understood that there are about forty different ways in which the apparatus can be used, but as the principle is the same in all, it will suffice to explain one only.

Let us imagine an ordinary telegraph wire from Lon-

don to Brighton, passing *en route* through Croydon and Reigate, and fitted with Morse apparatus at each end. If then a phonopore be joined to the wire at Croydon and another at Reigate, it will be possible for telegrams to be exchanged, by means of the phonopores, between Croydon and Reigate, without in the least disturbing or affecting, or being affected by, the ordinary Morse working between London and Brighton. The idea is not absolutely new, for it was shown some time ago by Van Rysselberghe that a wire used as a telegraph wire could also be used independently at the same time as a telephone circuit, and many of our readers will remember Edison's "phonoplex," a contrivance bearing a strong family likeness to that of Van Rysselberghe. Mr. Davies' invention would appear to be a new development of the same idea, but it has apparently the merit of being more practical. Perhaps the simplest way to obtain a grasp of the principle is by considering briefly the two prior inventions to which we have alluded, and this is the course we propose to adopt, taking Van Rysselberghe first and then Edison's phonoplex.

Fig. 1 is a diagrammatic representation of an elementary form of Van Rysselberghe's system, as worked between Brussels and Ostend. It consists of an ordinary telegraph wire fitted at each end with Morse apparatus, comprising a key, K, a printer, M, and a battery, B. To any two points—*a*, *a*—on the line are joined two branch wires passing to earth through a condenser, *c*', and a telephone, T. Between the battery, B, and the key, K, a large electro-magnet is inserted and two others, G, G, are inserted in the line. It is then possible for conversation to be carried on with the two telephones while the Morse apparatus is being used for telegraphic purposes. When the key, *k*, is depressed, the current from the battery has to pass through the two electro-magnets marked G G, one of those marked D, and the printer at the distant station. The insertion of all this resistance makes the currents sluggish, too sluggish, in fact, to affect the armatures of the telephones, which respond only to infinitesimally minute and rapid impulses. Every one knows that the large waves of the sea are covered all over with tiny wavelets. In the same way the great sluggish waves of

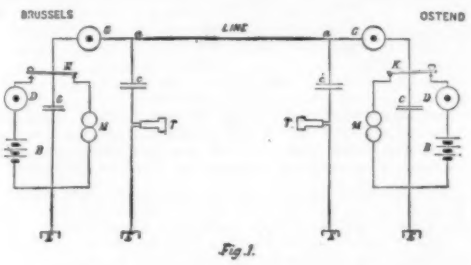


Fig. 1.

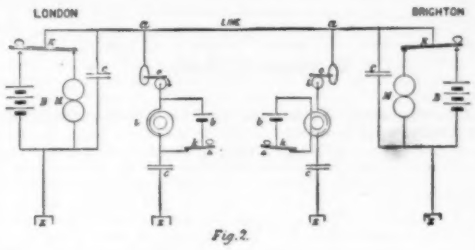


Fig. 2.

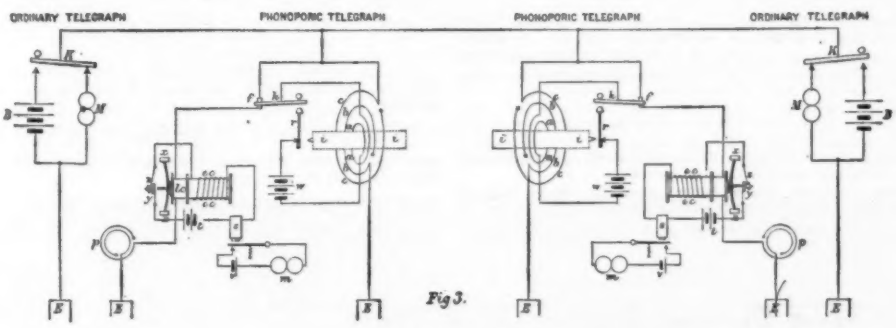


Fig 3.

electricity produced by the telegraph apparatus may be said to be covered over and permeated by the minute impulses or variations set up by the telephones.

The principle, then, is that two different kinds of waves are brought into play, a large slow wave and a tiny rapid wave, and the problem is how to use them on the same wire without mutual interference. The Van Rysselberghe system solves the problem successfully, and has only the drawback that owing to the resistance of the electro-magnets, the speed of the telegraph working is kept down to about thirty words a minute.

In Fig. 2, which represents Edison's so-called phonoplex, the connections of the telegraph apparatus at each end of the wire are precisely the same as in Fig. 1, and the points, *a*, *a*, to which the phonoplex apparatus is connected, may likewise be taken anywhere in the line wire. The apparatus consists of an induction coil, *i*, and a receiver, *e*. When the key, *k*, is depressed the primary circuit of the coil is opened, and when it is released the circuit is closed again; the breaking and making of the currents produced two minute and momentary impulses in the secondary circuit. The receiver, *e*, is Edison's electro-motograph, consisting of a telephone diaphragm, from the center of which projects a pin. The pin rests on the circumference of a revolving chalk cylinder, by the friction of which it is pulled except when a current is flowing. When a current flows the pin slips on the chalk, and the diaphragm vibrates so as to produce a sound. By an ingenious contrivance not shown in the figure, the sound produced by the making of contact differs from that produced by the breaking, and consequently the apparatus can be used for ordinary sounder working. The phonoplex, we believe, is open to the same objection as the Van Rysselberghe system, not being possible in conjunction with high-speed telegraphy.

A feature common to both these systems is the use of condensers, which are interposed in the branch lines between *a a* and the earth. In the phonopore, which we will now proceed to consider, there are no condensers; but the continuity of the circuit is interrupted by a device which serves the same purpose. The nature of this device is shown at *p*, in Fig. 3. It is practically an induction coil; one end of the inner or primary coil is put to earth and the other is left disconnected; and in like manner, one end of the secondary coil is left disconnected and the other is joined to the transmitting apparatus. These preliminary observations will prepare the reader for a more detailed examination of Fig. 3.

Here, again, the connections of the ordinary telegraph apparatus with its key, *k*, printer, M, and battery, B, are precisely the same as in the Van Rysselberghe system and the phonoplex; but the manner in which signals are sent and received in the phonopore is entirely novel. The apparatus consists of two parts, the transmitter and the receiver. The chief feature of the transmitter is a phonoporic induction coil having a soft iron core, *i*, *i*, which is shown in the figure by dotted lines. Round this core there are three distinct coils of wire, the primary, *a*, and two secondaries, *b* and *c*. When the key, *k*, is depressed a series of rapid currents is sent through the coil, *a*, from the battery, *w*, by way of the vibrating reed, *r*. Each of the two secondary coils has one end disconnected, but whereas the other end of *b* is connected to earth, that of *c* is connected to the line. The result of this arrangement is that the transmitter is at once an induction coil and a condenser. Its function is to send into the line a series of brief and rapid impulses, and their frequency, it is important to notice, depends on the note of the vibrating reed, *r*. While we are looking at the transmitter we should not omit to examine the disposition of the key, *k*. It will be observed that when the handle is depressed it strikes the piece of metal which holds the fixed end of the vibrating reed, and so communicates a jar to the reed which is useful in assisting to set up the needful vibrations. At the same time the other end of the key-lever as it rises from the backstop causes a disconnection at the point, *f*, so that whenever the transmitter is worked, the receiver is thrown out of circuit.

The receiving instrument, or transformer—so called because it "transforms" the intermittent impulses of the transmitter into continuous Morse signals—consists of a soft iron core round which two coils of wire are wrapped. The smaller of these, *l c*, is called the "line coil," one end going to line and the other through a small phonopore, *p*, to earth. The larger or extra coil, *e*, *c*, covers the remainder of the iron core. It will be seen that the wire of this coil, besides being wrapped round the core, passes through the uprighting sounder, *s*, and the battery, *t*. The only place where the circuit can be broken is at the point of contact between the two springs or vibrators and *z*. Whenever contact is broken here, the uprighting sounder, *s*, releases its armature, and the local battery, *v*, causes the printer, *m*, to work. But between the springs, *y*, *z*, and the core of the transformer, there is interposed a vibrating reed or disk, *x*, *x*, which is normally attracted toward the core and held in a state of tension by the current from the battery, *t*. Now let us suppose that the keys, *k*, *k*, are at rest and the Morse keys, K K, working. The currents from these affect the reed, *x*, slightly. The reed vibrates, but not enough to touch with its projecting spur the spring, *f*. If now the key, *k*, be depressed, it will send a series of rapid pulsations through *l c*, and as the reeds, *r* and *x*, are both tuned to the same note, these pulsations will cause *x* to vibrate so strongly as just to touch *y*. The contact between *y* and *z* being disturbed by the touch, the current in *e c* will be cut off, and the reed, *x*, being released from its tension, will strike *y* smartly with its spur as it straightens itself. When it is straightened it will continue to vibrate, thus preventing any efficient contact between *y* and *z*, until the pulsations in *l c* cease, and when these cease the apparatus will immediately come to rest again, the reed, *x*, being drawn away as before.

Such is the general principle of the phonopore, and those interested in telegraphy will be anxious to hear whether this arrangement has any drawbacks akin to those incident to the systems of Van Rysselberghe and Edison. At what rate it is possible to work the Morse keys, K K, without interfering with the phonoporic signals we do not know; but it is stated that the phonoporic keys, *k*, *k* can be worked at a very high speed. It is understood that the inventor is engaged upon a modification of the Wheatstone automatic apparatus, and that it has already been ascertained that the very rapid signals from this powerful instrument can be faithfully reproduced by the agency of the phonopore. If so, there is every reason to think that the new invention has a great future before it. We have only described a comparatively simple form of the apparatus, and we ought to add that it admits of being easily duplexed, and even of being "multiplexed," provided that the reed of each transmitter, while duly tuned to the reed of its corresponding receiver, differs in its note from the reeds of all the other transmitters and receivers.—*The Engineer.*

[Continued from SUPPLEMENT, No. 707, page 11298.]

SIBLEY COLLEGE LECTURES.—1888–89.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

VI.—SOME APPLICATIONS OF ELECTRIC TRANSMISSION.

By FRANK J. SPRAGUE.

THE principles which govern ordinary local distributions are applicable to a large part of the problems presented in the mining districts and need no especial elaboration, but there are some special features in long distance transmission meriting notice, and one of these is the application of series dynamos and motors where permissible.

While this type of motor does not ordinarily play a part in central station distribution, it has a field in the special transmission of power from one point to another in single units, or batteries, and the very characteristics which in the machines taken singly destroy their regulation become the very means for determining a very perfect regulation when coupled together. Suppose two such machines are running, one as a dynamo, and the other as a motor, let us see just what happens when the load varies, and in this way perhaps get a clearer idea of the methods and conditions of self-regulation than by a mathematical investigation. We will assume that a certain amount of power is being transmitted and the generator is being driven at a constant speed, its electro-motive force being, say, E, that of the motor *e*, and the resistance of the circuit R. The current then flowing is $\frac{E-e}{R}$, which passing through the field and armature of the motor produce the requisite torque. Suppose the load on the motor is increased, it tends to slow down. Its electro-motive force will consequently be decreased, and even with the same initial electro-motive force the current would be increased, thus increasing the torque and preventing any further reduction of speed.

This increase of current, however, acts upon the dynamo, increasing its electro-motive force, which tends to further augment the current, giving the motor more than sufficient torque to take care of its load. The only thing left for the moter to do is to increase its speed and by reducing the current restore the equilibrium, and if the machines are properly proportioned this recovery of speed will be exact. It is evident that, the current being the same in both machines, the ratio $\frac{e}{E}$ representing the electrical efficiency likewise represents the watt capacity of the two machines. It is further evident that this ratio is constant, and in order that this may be so, since both machines are excited by the same current and are run at the same speed, the characteristics of the two machines must be similar between the limits of automatic regulation. We see also that the initial electro-motive force, that of the motor and the current, all vary, not by like increments, but in the same ratio.

This same method of regulation can be applied to a battery of machines in series transmitting power to another battery of machines likewise in series. In this method of transmission, where large powers, long distances, and necessarily high potentials are used, it is advisable to divide the generators and motors into a battery of machines of identically the same weight and character, the number of the machines being the ratio of the electrical efficiencies, the generators all to be driven from the same line of shafting, and the motors to drive on to a common line, and the current to pass through all the machines in series. This I consider the best method when dealing with large powers and high potentials and single units of generation and recovery, especially where automatic regulation is required.

Its advantages are manifest. One of the greatest difficulties which we have in dynamo-electric construction in closed circuit machines, especially where using the drum system of winding, is the difficulty of securing perfect insulation when high potentials are used.

A potential of 1,000 or 1,200 volts seems as high as it is now advisable to go in machines of this type, when currents of any magnitude are to be used. In the transmission of electricity, reliability is an essential, and a potential of 3,000 or 4,000 volts, distributed over three or four machines in series, is, despite the increased number of machines, far less liable to cause failure than where put into one machine of the aggregate size of the four. In the event of the breaking down of one machine, the units may be so proportioned that, by a corresponding change in the units at the other station, or a proper variation of the regulating shunt to the fields, it becomes quite possible to continue automatic operation. As an illustration of this distribution of machines, if wishing to use dynamos and motors of an electrical efficiency of about 95 per cent., a commercial efficiency each of about 90 per cent., and with about 60 per cent. as the commercial efficiency of the circuit, I would, with a distance of about nine miles, use five series machines identical in construction, each wound for about 1,200 volts, three of which machines would be driven by a common line of shafting at the generating station and two driving on to a common line of shafting at the receiving station. It will be noticed that both in the single and multiple unit series system, the electro-motive force and the current vary equally.

It is highly probable that in the near future the transmission of large units of power over considerable distances for mining work will be a matter of common practice, and since the money values are large, it is of prime importance that well settled and correct engineering practice shall obtain.

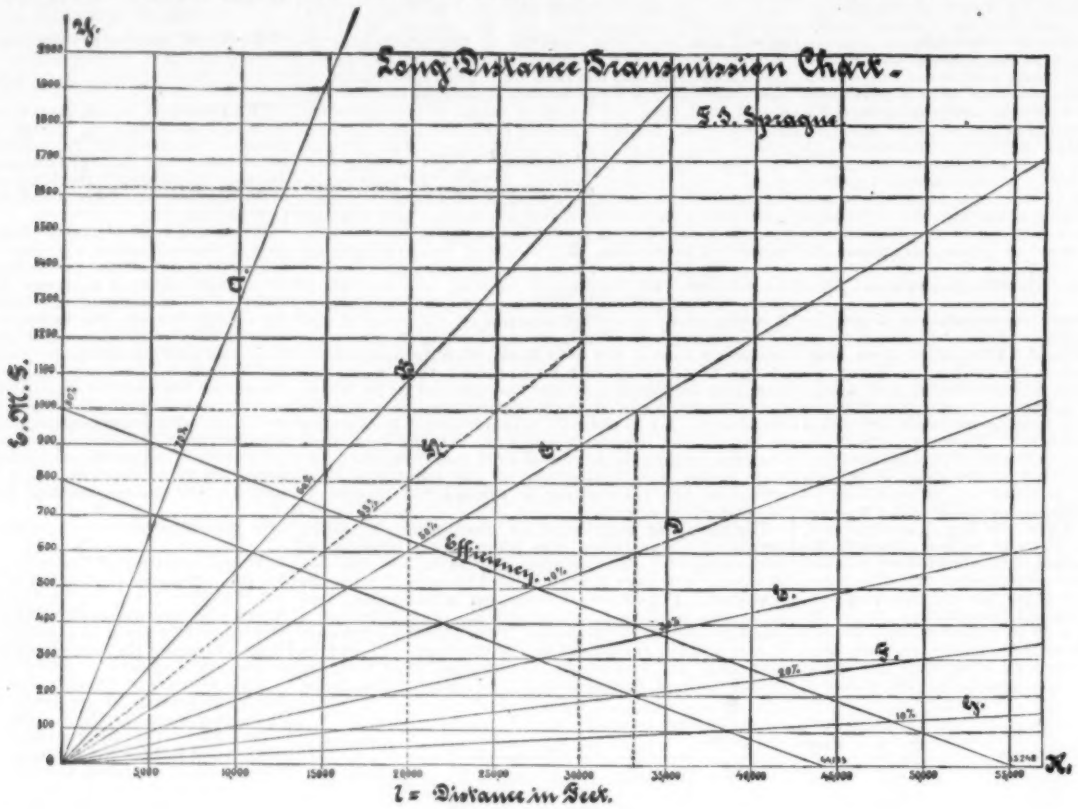
First investment is always of serious consideration, and I have on this account been led to make some investigations leading to conclusions not heretofore generally accepted, relating to proper cost of a plant and the relation of the investments of the various parts of an installation. I find in this investigation that some very curious and valuable facts may be demonstrated by a formula for determining the *minimum* cost of plant, where the amount of power at the generating station is practically not limited, and where there is no line loss from leakage, the line loss being measured simply by the fall in potential.

The cost of a plant of this character can be divided into five parts, that of the motors, the conductors, the line erection, the dynamos, and the power plant, whether water or steam. I will assume that the cost of the dynamos and motors is the same per horse power or other unit, no matter what the electro-motive force used. While this is not strictly true, for all practical purposes, with large units, and speaking from the commercial standpoint, it can be so assumed. This being the case, for any given power the cost of the motor is a constant, independent of the potential used. With any given motor potential, the greater the loss on the line, the less the cost of the conductors, but the greater the cost of the generators. On the other hand, the less the loss on the line, the greater its cost, but the less the cost of the generating plant. It follows, then, that the least cost of plant is determined when the variation in the cost of the generator is equal to that in the cost of the line.

Without going into the detailed formulæ, which lack of time forbids, I may state that a general expression for the cost per horse power delivered is as follows:

$$C = \frac{E + v}{E\,\alpha\,\beta}(K + L) + \frac{2984\ m\ l^2\ d\ b}{E\ v\ \alpha} + M + \frac{P}{n}$$

where E is E. M. F. at the motor terminals; v, the fall of potential on the line; L, the commercial efficiency of the motor and B that of the dynamo; K, the cost in cents of the motive power per H. P. and L that of the dynamo per H. P. required to drive it; m, the resistance and d the weight of 1 mil-foot of copper; l, distance in feet; b, cost of conductor per pound of copper including insulation; M, the cost of motors per H. P.; n, the number of H. P. delivered to the motor; and P, the cost of pole and line erection.



This expression is variable, and we find the condition for a minimum is when

$$\frac{K + L}{\beta} = \frac{2984\ m\ l^2\ d\ b}{v^2}$$

whence

$$v = 54{\cdot}6\ l\sqrt{\frac{m\ d\ b\ \beta}{K + L}}$$

which substituted in the general equation gives us

$$C = \frac{E + v}{E\,\alpha\,\beta}(K + L) + \frac{v}{E\,\alpha\,\beta}(K + L) + M + \frac{P}{n}$$

By introducing a term, λ, for the commercial efficiency of the circuit, the cost equation further reduces to

$$C = \frac{K + L}{\lambda} + \frac{\alpha\,\beta - \lambda}{\alpha\,\beta\,\lambda}(K + L) + M + \frac{P}{n}$$

in which the first term gives the cost of generating plant, and the second that of the wire.

These formulæ show some peculiar facts, among which may be mentioned the following:

With fixed conditions of cost and efficiency of apparatus, the number of volts fall to get the minimum cost of plant is a function of the distance alone, and is independent of the electro-motive force used at the motor.

With any fixed couple and commercial efficiency, the cost of the wire bears a definite and fixed ratio to the cost of the generating plant.

The cost of the wire varies directly with the cost of the generating plant.

If we do not limit ourselves in the E. M. F. used, the cost per H. P. delivered exclusive of line erection is, for least cost and for a given commercial efficiency, absolutely independent of the distance.

The graphic representation of these facts and the determination of the elements of transmission is a simple matter where certain constants are known.

One of the equations which may be deduced by substituting the proper values with good machines is

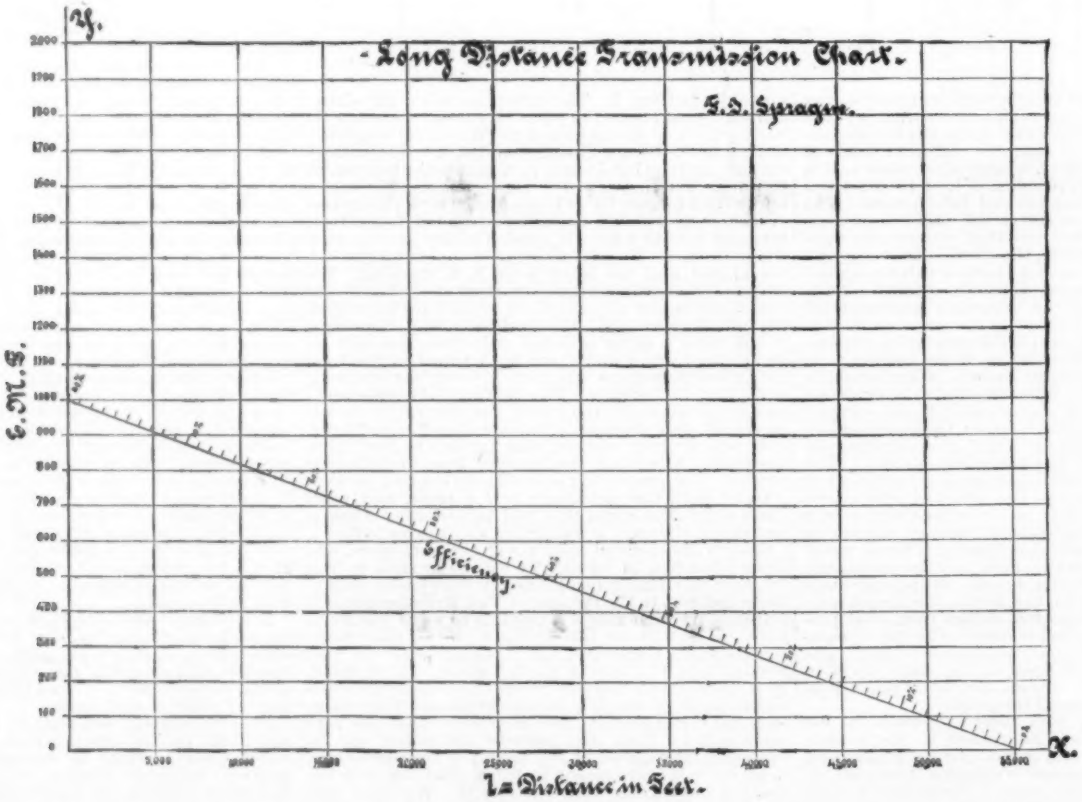
$$E = \frac{0{\cdot}0905\ \lambda}{4 - 5\ \lambda}\ l$$

Let us lay off on the axis of x the distance in feet and on the axis of y the E. M. F. at the motor terminals.

Then for any value of λ the ratio of $\frac{E}{l}$ is fixed, whatever the actual value, and we can draw the efficiency lines, O A, O B, etc., for

$$\lambda = 70 \text{ per cent., } 60 \text{ per cent., etc.,}$$

which will, with the different values of l and E, give



us any required information. This, however, is not yet in a convenient and general form, and we wish to get some general intersecting efficiency line.

By an inspection of the diagram, we see that if a general efficiency line can be drawn, it must intersect

the specific efficiency lines at such an angle that the intersected portions must be proportional to the differences of efficiencies.

In other words, we must have the ratio $\frac{E}{\lambda}$ for any particular value of E constant. Referring to the above equation and transposing, we have

$$\frac{E}{\lambda} = \frac{5\,E + 0{\cdot}0905\,l}{4}$$

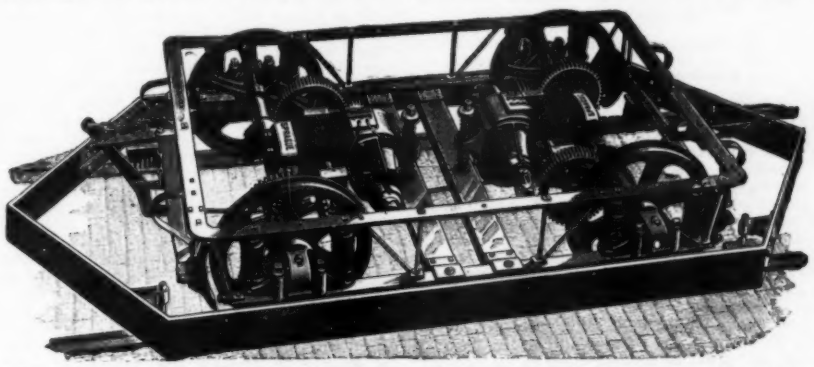
It is evident that this equation is that of a straight line when $\frac{E}{\lambda}$ is a constant, which we will call r.

By giving r any particular value, we can plot a general efficiency line. Assuming another value for r, we get another straight line parallel to this, but one line is sufficient. It is, however, of prime importance. On it we lay off the efficiency percentages in equal increments from 0 to 80, and the chart, which need consist only of the axes of x and y, on which the E. M. F. and distance are laid off, and the efficiency intersecting line is ready for constant reference, and will give at a glance the graphic solution of all the ordinary elements of a transmission under the condition of least prime cost, with a known efficiency and cost of motors and dynamos and cost of copper. For example, suppose we wish to transmit a distance of 30,000 feet at a commercial efficiency of 60 per cent., what would be the required E. M. F. at the motor terminals? Drawing the efficiency line, O B, till it meets the ordinate erected at b 30,000, we find the E. M. F. to be 1,620 volts. On the other hand, suppose we are limited to 1,000 volts at the motor, and must have an efficiency of 50 per cent., what would be the limiting distance? Reversing the above process, we find it to be 33,500 feet. Suppose, again, that we must operate at a distance of 20,000 feet, and are likewise limited to an E. M. F. of 800 volts at the motor, what would be the required efficiency? Through the intersection of the co-ordinates of electro-motive force and distance, we draw the efficiency line, O H, and at its intersection find the efficiency to be about 55¼ per cent. Such, then, is this method of graphic determination. While manufacturing practice and change in market rates will not always permit us to follow this method of determination exactly, it is a guide which tells how far we can deviate without material loss.

One of the most important and rapidly growing applications is that to street railways, and in such application we have to consider, first, the generation of the current; second, delivery to the motors; third, the method of mounting and gearing the latter, and finally the method of control.

Commercial and mechanical considerations must together settle these different points.

The generating plant consists, of course, of two parts, the prime movers, whether of water or steam, and the dynamos. Although in exceptional cases water may be used as a source of power, its scarcity and the extreme rarity in which it will be found in a favorable position leave us generally the only alternative, that of steam. It goes without saying that such a power plant should be well designed. If high speed engines are used, it is generally best to connect each engine to a pair of dynamos; if low speed engines are used, they should all be coupled to a line of countershafting equipped with friction clutches, and the dynamos be driven from this line of shafting. By this method any engine can drive any set of dynamos up to its capacity. Up to the present, single-acting engines have been generally used, but as the work progresses and enlarges, it is quite probable that compound engines, and oftentimes condensing as well, will be used.



VIEW OF INDEPENDENT STREET RAILWAY TRUCK, EQUIPPED WITH SPRAGUE IMPROVED ELECTRIC MOTORS, SHOWING METHOD OF FLEXIBLE SUSPENSION, AND OTHER DETAILS.

A constant potential circuit, which is the only one worthy of serious consideration, being used, we naturally have for our generators dynamos either wholly or chiefly excited from a shunt coil; that is, either the simple shunt machines or the compound-wound machines. Each has its advantages. If no short circuits occur on the line, then the compound machines will be better; but if short circuits and like troubles should frequently occur, then the simple shunt machines are preferable. And no matter whether shunt or compound machines are used, they should be provided with means for varying the strength of the magnets. The details of the station are very similar to those existing in an incandescent electric light station.

In the application of electricity we are theoretically not limited to any one system, but have a choice which will permit us to meet any of the exigences of service. There are two kinds of application.

In one, each car is perfectly independent of the other, receiving its charge at the central station and acting as an individual unit. The storage battery method is such a system.

The other is a system of direct supply, and, unlike the battery system, where the energy of the steam is four times converted, it suffers only two losses. In this system the current is delivered directly to the line, from which the motors, as they move along, derive their current. There are several forms of conductors, center and side rails, the main tracks, conductors carried in conduits and overhead. Either a complete metallic circuit may be used, or one conductor with the rail and earth return. The machines can be operated under three different systems—the series, multiple series, and parallel circuit distribution.

Of these various plans, I shall discuss only three, the storage battery, the conduit, and the single overhead wire system with underneath contact carried on the car, and for the systems of distribution the parallel circuit system only.

VIEW OF ELECTRIC CAR ON BROOKLINE BRANCH OF WEST END ROAD, BOSTON, MASS.

The storage battery from the time of its first introduction to the public has offered a tempting solution to the application of electricity for surface transit. The great advantage of the battery system when properly developed will be the fact that each car is in itself for the time being an independent unit, not dependent upon any immediate general accident to a system. As attractive a solution as the storage battery at first sight seems, there are many points of disadvantage in the present state of its development. One of the most important is the excessive weight of battery which is necessary under the conditions of service which are met with in this country, from 3,400 to 4,000 pounds being the ordinary weight. Not over 10 per cent. of the lead in these batteries is actually used for storage. On account of the weight and the room which the battery takes up, there has to be a radical change in the construction of the cars, and while old cars can be made use of by a great deal of patching, it is not advisable to attempt this. This change makes the present cars nearly useless, and likewise increases the cost of new car bodies.

Then again, while the tracks as they exist may stand the additional weight of motors on a four-wheel car, the additional weight of battery, making the total weight on a given wheel base double what it was before, will render it necessary on a great many tracks to relay the roadbed or to put in eight-wheel cars. Of course these objections are not so serious on a new road as they are on an old one.

But I confidently expect to see, in the not so very distant future, the weight of battery necessary to handle a car reduced one-half; this, besides overcoming some of the objections which exist now, will halve the expense of handling them at the central station, and will also allow the present standard width of aisle to be maintained.

The present excessive cost and unknown depreciation of the battery, its lack of efficiency, limited capacity, the fact that only a portion of the charge can be taken out with safety, and the reduction of its output when sudden demands are made upon it, are all of such a character as to leave wide room for improvement. The loss of efficiency in conversion I do not esteem of such vast importance, because in any large system where the engines are kept going under a steady load, the cost of operation will not be so very much more than where operating under continually varying loads. The limited rate of discharge, as well as the limited capacity, limits the grade work to which a battery car can be subjected. For instance, as batteries are now ready and used, we may have a weight of ten tons in each car unit to handle.

To start and to accelerate this load on say six per cent. grade demands a discharge rate which no storage battery company cares to recommend.

As near as it is possible for us to get at a correct estimate, on a new road of moderate grades, a storage battery system could be operated at about 80 per cent. of the cost of operation by horses. This is about double the cost of the direct system of supply on a large scale.

But the storage battery is not going to stand still.

Many men with abundant capital are striving for improvement, and I think there is but little question that batteries will be reduced in weight, increased in capacity, and made far more efficient and long-lived.

The conduit and overhead systems have one point in common. Both are dependent upon a central station, and the actual cost of operation (except for the care and maintenance of the conduit itself and its appliances) would be about the same. There is, however, a great difference of investment. Both must have about the same amount of copper and, to be effective, about the same distribution.

The difference of cost is practically the difference between pole line erection and conduit laying, and this will be from $25,000 to $40,000 per mile. As an investment, of course, it means that with the conduit very much more money has to be earned. The electrical conduit can be built for less money than a cable conduit, because it can be made of less depth, but it cannot be built without due regard to the strains of street traffic and weather, and with proper drainage and cleaning facilities. The advantages claimed for the conduits are chiefly that there are no overhead obstructions. Its disadvantages are, besides its great cost, the lack of cleanliness, increased possibilities of leakage, and greater difficulty of repair in case of accident as now put in. Delays in Boston of several days and in Allegheny City of two weeks show somewhat forcibly this fact. (Since writing the above, the abandonment of the conduit in Boston has been determined upon.)

If a conduit is used, the working conductor should be divided into sections, which at intervals of every block or half block, as desired, are connected through automatic cutouts in manholes to the main conductor, which is continuous and inclosed in a lead or iron covered cable. Any accident to a section, such as flooding, short-circuiting, etc., will simply cut out that particular block.

For the immediate solution of the question of more rapid and cheaper transit in many places, the overhead system is most available. Without going into the discussions which are generally raised concerning overhead wires, and which have their basis chiefly in the fact that municipal privileges are abused, and work done in a slovenly and dangerous manner, the fact remains that a proper overhead wire system has the great advantage of cheapness, ease of manipulation, and accessibility, qualities which we cannot afford to disregard. Hence I will briefly point out the salient features of the different methods of overhead work, and describe more in detail the latest and most marked development of it—that on the Allston division of the West End railway in Boston.

There are two general methods of working; in one a complete metallic circuit being carried overhead, and in the other one circuit is made through the rail. Two methods of taking of the current prevail—one by means of a carriage traveling on the overhead conductor or conductors, the current being conveyed to the car by a flexible cable, the other by means of a universally flexible arm on the car, making underneath contact with the trolley wire. Again, two methods of supplying the current exist, one in which the trolley wire is the main as well as the working circuit, and in the other the trolley wire is the working circuit only, while the main circuit is carried along independently and electrically joined at intervals by the working circuit.

The question whether a complete metallic overhead

system should be used or a single trolley and a ground return is much more important than appears at first sight. Æsthetically speaking, the greater number overhead, the more objectionable they are, especially when those wires are in the middle of the street. For a simple straight road of definite length, no particular difficulty is encountered in either system, but the moment the work enlarges, single and double tracks, cross-overs, sidings and curves come into use, then the difficulties of a two-wire system become very manifest. Reliable automatic switching becomes an impossibility. The increase in the size of poles and their frequency, the increase in the size of the span wires and even of the conductors themselves, and the multiplicity and complication of the supporting and guy wires at all deflections from a straight line, and the entirely unsatisfactory character of the switches, all combine to make most serious trouble. On the other hand, the use of a single trolley wire increases the distance between the poles, makes the poles and span wires lighter, reduces the complication at all switches and curves, and mechanically speaking is unquestionably safer. Where this trolley wire is made simply subsidiary to a main wire carried alongside of the street or underground, as in our main and working conductor system, its size is the same independently of the number of cars operated, or the distance over which the road extends, or the grades which may be encountered, and the advantages of a single trolley system are even more manifest. We can go still further with this system. The main conductor in a city can be laid underground, and the larger the number of cars, the more extensive the road, the greater the percentage of underground work, the overhead work remaining constant in character and amount. It is at this point in which electric railways differ from all other overhead service. The telegraph and the telephone wires increase and multiply as the service is increased and in at least direct proportion thereto, while that part of an electric railway service which is overhead may be made as little obtrusive for one hundred cars as for one.

As between the methods of taking the current off the overhead wire by a trolley supported by and traveling upon it, or a trolley pressing up underneath the wire, there can be little question, at least in the minds of those who have used both systems. In the latter case, there is little liability in a well built line of the trolley wheel ever leaving the wire, it is on the car under the immediate and positive control of the conductor, and no matter at what speed the car is moving, or whether it be day or night, the trolley can be replaced at once from the car if it should leave the wire, which manifestly cannot be done with a traveler supported by and carried on the wires themselves.

The single trolley system further offers advantages. It reduces the strain on the wires. It permits higher safe speed. It can be divided into sections and the main wire can be divided into corresponding sections, so that not only main divisions can be cut out, but likewise any subsidiary division. This plan is adopted on the Allston division of the West End R.R. in Boston, Mass. There we have four main divisions supplied by two main feeders, which divisions as a whole can be cut out one or more at a time, and, furthermore, parts of each division can likewise be cut out. Where the main conductor system is used with a ground circuit, the track is likewise a working conductor, and re-enforced by a continuous main conductor connected with the station.

(To be continued.)

SPEED OF PASSENGER TRAINS IN THE UNITED STATES.

THE accompanying table gives the speed of the fastest passenger trains and the average speed of all passenger trains between most of the principal cities of the United States. The times and distances are taken from the "Traveler's Official Guide" for July, 1888. The average distance between the stations at which the fastest train is timed to stop is also given where possible. The time on which the speed is calculated includes all stoppages, and no allowance or deduction is made for ferries, etc. It is believed that in every train given in the table, through cars of some description are run between the termini given, though in some cases no sleepers are run, and in others the sleepers only are run through.

The trains given in the table either run between or pass through thirty-six of the principal cities in the United States, and it is believed that Denver and Indianapolis are the only important omissions. The case of Brooklyn is of course exceptional. Care has been taken to make the table as accurate and representative as possible, but some errors are unavoidable.—*Railroad Gazette.*

Speed of Passenger Trains between Principal Cities, July, 1888.

Whence—Whither.	Route.	Fastest train. Distance. Miles.	Time. Hrs.	Time. Min.	Speed. Miles per hour.	Average distance between stopping stations. Miles.	No. of trains each way per day.	Average speed of all trains.
New York—Philadelphia	Philadelphia and Reading	90·4	2	9	42·0	12·9	10	32·6
"	Pennsylvania	90·8	2	8	43·6	22·7	23	34·5
" —Washington	"	226	5	22	40·3	?	9	34·5
" —Pittsburg	"	444	11	30	38·6	89	4	31·6
" —Chicago	"	912	25	0	36·5	102	4	29·9
" "	N. Y. Central and Lake Shore	961	25	0	39·1	109	4	32·7
" "	" and Mich. Central	977	28	30	34·3	28·7	3	30·9
" —Buffalo	New York Central	441	10	45	41·0	110	5	34·8
" "	Erie	423	13	0	32·5	21	3	31·3
" "	Lackawanna	409	12	40	32·3	16	2	29·9
" —Boston	Boston and Albany	234	6	0	39·0	33·5	4	35·4
" "	New York and New England	213	6	0	35·5	53	5	31·1
" "	Shore Line	229	6	0	38·2	32·7	4	32·7
Baltimore—Chicago	Baltimore and Ohio	853	25	40	33·2	25	*2	29·5
" "	Pennsylvania	801	23	15	34·4	33	4	28·5
Chicago—Minneapolis	C., M. and St. Paul	420	14	40	28·6	15·0	3	27·0
" "	C. and North-western	419	14	33	28·8	18·0	2	27·5
" "	Wisconsin Central	472	15	5	31·3	30·0	2	28·7
" "	C., St. Paul and Kansas City	431	15	0	28·7	22·7	2	26·8
" "	C., Burlington and Northern	442	14	37	30·2	19	2	28·3
" —Kansas City	C., Burlington and Quincey	487	15	40	31·1	24·3	2	26·8
" "	Chicago and Alton	488	15	20	31·5	30·5	3	25·0
" "	C., Rock Island and Pacific	521	16	35	31·5	—	2	27·3
" "	C., Santa Fe and California	488	20	25	22·4	24·1	2	21·7
" —Omaha	C., Burlington and Quincey	508	16	20	31·1	30	3	28·5
" "	C., Milwaukee and St. Paul	490	18	45	26·1	9·4	2	25·0
" "	C., Rock Island and Pacific†	500	16	0	31·2	16·5	3	26·5
" —St. Louis	Chicago and Alton	283	10	35	26·7	?	3	26·1
" "	Wabash	286	9	50	29·1	8	2	25·2
" "	Illinois Central	299	10	30	28·5	?	2	26·0
" —New Orleans	Illinois Central	915	35	0	26·1	19	2	25·0
Cincinnati— "	Cin., N. O. and Texas Pacific	836	25	35	33·3	69	2	27·5
Louisville— "	Louisville and Nashville	811	25	0	32·4	22·3	2	29·0
Savannah—Atlanta	Central of Georgia	295	10	20	28·5	10·3	2	28·2
St. Louis—Galveston	Missouri Pacific	1014	46	55	21·4	10·4	1	21·4
" "	Iron Mountain	869	35	55	24·2	13·6	1	24·2
Omaha—Ogden	Union Pacific	1031	36	10	28·5	38	2	24·7
Ogden—San Francisco	Central Pacific	834	37	45	22·0	12	2	21·5
San Francisco—New Orleans	Southern Pacific	2405	113	25	22·0	?	1	22·0
St. Paul—Portland	Northern Pacific	1913	74	20	25·7	31	2	22·8

* Vià different routes. † To Council Bluffs Transfer.

[Continued from SUPPLEMENT, No. 707, page 11293.]

RECENT DEVELOPMENTS IN HIGH EXPLOSIVES.*

By PERRY F. NURSEY.

CARBO-DYNAMITE.

THE author now comes to the later developments of nitro-glycerine compounds, the first of which for notice is carbo-dynamite. This explosive is of British origin, and is the joint invention of Mr. Walter F. Reid and Mr. W. D. Borland. It is composed of ninety parts by weight of nitro-glycerine absorbed by ten parts of a variety of carbon, the greater porosity of which is indicated by its absorbing power. Nor is the high rate of absorption it possesses its only good mechanical feature; it is extremely retentive, which adds greatly to its value as an explosive agent. It possesses several important advantages over ordinary dynamite, which, as has been stated, consists of 75 per cent. of nitro-glycerine mixed with 25 per cent. of kieselguhr, which latter, being incombustible, cannot add to the force of the explosion, and must be looked upon as an adulterant of the nitro-glycerine, so far as explosive effect is concerned.

Carbo-dynamite, on the other hand, not only contains 15 per cent. additional nitro-glycerine, but the absorbent substance, besides acting as a safe carrier for the nitro glycerine, is itself combustible and adds to the explosive effect. The new explosive, therefore, contains 100 per cent. of actual explosive substance. Carbo-dynamite, moreover, is not hygroscopic, water apparently having no action upon it. The author has examined some of this compound which had been immersed in water for nearly six weeks, but which had not undergone the slightest change, nor was there any exudation.

Some ordinary dynamite, placed in water at the same time as the carbo-dynamite, had become dissolved, and the nitro-glycerine was lying at the bottom of the water. This freedom from exudation points to the use of carbo-dynamite in fiery mines. Being unaffected by water, it may be mixed with it in any required proportion. It is claimed that the volume of steam generated at the moment of explosion not only extinguishes any flame which may be produced, but also adds considerably to the effect of the shot. Another advantage is that the explosion of carbo-dynamite does not result in the production of fumes of a deleterious nature. It is further claimed that the explosive force of carbo-dynamite can be regulated.

In April, 1888, the author was present at some experiments and also some practical trials which were made with carbo-dynamite at Treherbert, Rhondda valley, South Wales, at the instance of the carbo-dynamite syndicate. In the first experiment a 21 foot length of double-headed 80 lb. steel rail was placed on its side on supports 9 inches high and 12 feet apart, and 1¼ oz. of carbo-dynamite was laid on the rail and tamped with clay. The explosion broke the rail in two, cutting out about 9 inches and embedding the fragments in the earth. In the next experiment a 1 inch borehole 18 inches deep was made in a large bowlder of tough sandstone weighing about 35 cwt.

The hole was charged with 2 oz. of ordinary dynamite and fired, the shot splitting the stone up into one large and several smaller pieces. A similar charge of carbo-dynamite was placed in a borehole in a larger stone of the same character, partly embedded in the earth. The explosion shattered the stone to a much greater extent than in the previous case, and on examination it was found to be a denser rock, but it was stratified, and disruption was therefore rendered more easy, so that the explosive did not have a fair chance.

The more practical trials took place in the heading of a tunnel half a mile from the mouth, the tunnel being in course of construction on the Rhondda and Swansea Bay Railway. The tunnel, which is 2 miles in length, runs through a hard sandstone approaching quartzite in texture, and near the end two holes, each 3 feet 9 inches deep, had been bored. The first was charged with 16 oz. of carbo-dynamite and a primer, and fired. On immediately returning to the spot, not a trace of noxious fumes could be detected in the smoke from the fuse. The second hole was charged with 16 oz. of ordinary dynamite and a primer, and fired, and upon returning to the spot noxious fumes were distinctly discernible in the powder smoke from the fuse. It was, moreover, considered by those in charge of the work that the carbo-dynamite shot got more ground than the ordinary dynamite. Some comparative experiments were afterward made to demonstrate the superior power of carbo-dynamite over ordinary dynamite. Here two lead cylinders were used, each weighing 40 lb. and measuring 8 inches high by 4 inches in diameter, bored with a 1 inch central hole 6 inches deep. In one a quarter of an ounce of carbo-dynamite was placed and tamped with sand, and in the other a similar charge of ordinary dynamite similarly tamped. They were both capped and fused and fired, detonators and miners' safety fuse being used throughout the experiments. On examination it was found that the carbo-dynamite cylinder had a spherical expansion around the region of explosion 5⅓ inches in external diameter, while the original capacity of the borehole, which was equal to 78 cubic centimeters, had become increased to 590 cubic centimeters. The external diameter of the ordinary dynamite cylinder measured around the spherical portion was 4¾ inches, and the internal capacity had become increased from 78 cubic centimeters to 347 cubic centimeters, showing a heavy percentage in favor of carbo-dynamite.

This explosive is not yet manufactured in this country, but arrangements have been made to import and store it here for the market. The home office authorities have also authorized a modification of carbo-dynamite containing 50 per cent. of nitro-glycerine with potassium nitrate and cork carbon. This, it is stated, is somewhat stronger than No. 1 dynamite, and can be produced at a lower price. The author has satisfactorily used carbo-dynamite in a blast 400 feet from surface and under a 350 foot head of water. The details of this shot will be given later on.

VON DAHMEN'S SAFETY DYNAMITE.

The latest developments in explosives of the nitro-glycerine class is the safety dynamite which has been invented by Baron Von Dahmen, and which has a very direct bearing upon the question of safety. Those who are familiar with explosives are well aware that a serious element of danger in the use of ordinary dynamite arises from its liability to freeze and solidify at a comparatively high temperature. This solidification commences somewhere about 40° Fahr., and increases rapidly as the temperature is lowered. In its frozen condition dynamite becomes inert, and cannot be exploded, which renders it useless until thawed. Thawing has therefore to be resorted to, and it is this process which constitutes the danger, and which, in fact, is a very fruitful source of accident. Not but what if thawing be properly carried out—and it can be—it is a perfectly safe process. It consists in placing the frozen dynamite in a covered tin can, which fits into the top of a tin kettle containing warm water, into which the can dips. The arrangement, in fact, is similar to that of a glue pot, the dynamite being thawed by the application of a gentle warmth. Every miner or quarryman is, or ought to be, provided with one of these thawing kettles, but, as a matter of fact, miners and quarrymen are notoriously addicted to neglecting its use and to thawing dynamite in their own reprehensible way. This consists in placing the frozen dynamite before a blazing fire, in an oven, or on the heated hob, and the records of dynamite accidents show how persistently some men will follow this baneful practice in spite of the warnings conveyed by accidents of this class to others. Miners and quarrymen are, however, not the only sinners in this respect, for thawing cans are not always provided, and often, when provided, their use is not sufficiently insisted on. The necessity for thawing, however, is entirely overcome in the Von Dahmen safety dynamite, which was submitted to the author for trial in January last, and with which, in conjunction with Mr. C. Napier Hake, he carried out some experiments.

This new explosive consists of the ingredients of ordinary dynamite, but to which is added a small proportion of another material. It is this addition which not only prevents the dynamite freezing and becoming inert, but causes it to retain and develop its full vigor when detonated at very low temperatures. The experiments were made comparative with ordinary No. 1 dynamite, in order to ascertain, in the first place, whether the two explosives became solidified at a very low temperature, and, if so, whether they could be exploded with useful effect when under the influence of that temperature. It was further desired to ascertain whether the power of either of the explosives was affected by a greatly reduced temperature. In the first place, equal quantities of dynamite and safety dynamite were exploded at the ordinary atmospheric temperature, neither of them having been refrigerated. As a matter of course, the dynamite exploded readily with a good result as regards strength. The safety dynamite was also readily exploded, and with a better result as regards strength.

The next experiments were made with equal quantities of dynamite and safety dynamite, both of which had been submitted to a temperature of —15° to 20° Cent. (—18° Cent. being equal to zero Fahr. or 32° below freezing point) for twenty-four hours. At the moment of use each explosive had a temperature of —15° Cent. The dynamite was frozen so hard that it was impossible to make a hole in it to insert the cap-

* A paper read before the Society of Engineers, London.

ped fuse. It was, in fact, as hard as a piece of wood. The cap was, therefore, attached to the side of the bare dynamite, but on firing the charge the cap alone was exploded. A great contrast was presented by the safety dynamite, which at the same temperature remained perfectly soft and plastic. The capped fuse was easily inserted in it, and it was exploded as readily as though it had never been refrigerated. The dynamic effect was very good, and only to the slightest extent inferior to that obtained with the same explosive in its ordinary condition.

We then compared the behavior of the refrigerated safety dynamite with that of frozen ordinary dynamite with the capped fuse attached to the side of the dynamite, instead of being within the charge. The capped fuse was therefore attached to the side of a cartridge of refrigerated safety dynamite divested of its paper wrapping. The charge exploded just in the same way as did the cartridge of refrigerated safety dynamite with the capped fuse inserted in it, and with a similar result as regards work done. In order to test whether a charge of refrigerated safety dynamite could be exploded by the explosion of a charge of the same compound when detached from it, two cartridges of refrigerated safety dynamite, divested of the wrapping paper, were placed end to end, with an inch space between them, and one was exploded with a capped fuse, the result being that the second cartridge was also exploded. Safety dynamite has also been subjected to careful examination from a chemical point of view and severe testing by Mr. Hake, who reports the process of manufacture to be a comparatively simple one, and the nitrating process to be apparently more rapid and attended with less risk than the ordinary method of nitration. The results of tests made with ordinary dynamite and safety dynamite, in order to ascertain their relative sensitiveness to concussion, lead to the conclusion that safety dynamite is considerably less sensitive to concussion than ordinary No. 1 dynamite. The same remarks also apply to safety nitro-glycerine and ordinary nitro-glycerine.

Taking the results of the experiments as they stand, the author cannot evade the conclusion that Baron Von Dahmen has succeeded in greatly lowering the freezing point of this useful blasting agent. To put it correctly, he has succeeded in producing an uncongealable dynamite, for as yet its freezing point has really not been reached, although the endeavor has been made to reach it, but in vain. The safety and usefulness of dynamite are thus greatly enhanced, for, as already observed, it is in thawing dynamite that the great bulk of accidents happen.

HENGSTITE.

It will be seen that the author has only noticed those high explosives which come more especially under the denomination of blasting agents, those having reference to military and sporting purposes not having been referred to. His reasons for this were twofold; in the first place he desired to present the subject to the Society of Engineers from an engineering standpoint, and in the second he did not wish to unduly encumber his paper. He is obliged, however, to make one exception to the rule he has hitherto observed, and this exception is admissible, inasmuch as it relates to a new powder, which possesses the double advantage of being useful both for blasting purposes and for arms.

This powder is the invention of Mr. C. F. Hengst, and it has straw pulp as a base, the pulp being treated first with acids, and afterward with alkalies. The resultant is a fine fibrous substance, which is granulated for military and sporting purposes, and compressed for blasting purposes. For this powder the claims are advanced that it is smokeless, flameless, non-fouling, and non-heating. It is also claimed that the recoil and report are less than, and the penetrative power and uniformity equal to, those of black powder, with greatly reduced charges. In February last the author was commissioned to investigate the merits of this powder from a practical point of view and to ascertain how far the claims made for it could be substantiated. In order to do this he first carried out a series of experiments to test it as a military and sporting powder, and afterward tried it for blasting purposes. The first experiments were carried out at the testing ranges of Messrs. Cogswell & Harrison, at Harrow. The experiments were made comparative with black powder, and in the trials having reference to military use the government pattern Martini-Henry rifle and ammunition were used. The charge in the case of the black powder was 85 grains, as against 35 grains of hengstite, all other details remaining the same. Considering that the latter powder was only produced experimentally and in small quantities, the results were very satisfactory. The velocities, which were taken by a chronograph, were a little lower and a little less uniform than those of the black powder. A grain or two more powder would probably have set the velocities right, but would hardly have affected the question of uniformity. That must remain for practical manufacture on a large scale. The wonder, perhaps, is that in the circumstances the want of uniformity was not greater than it was.

The foregoing remarks apply also to hengstite as tested in relation to sporting purposes. Here the charges were respectively 83 grains of black powder and 33 grains of hengstite, the weight of shot, the gun, and other details being the same in both cases. These rounds were fired from a rest, the recoil being recorded. The recoil was less with hengstite than with the black powder, but the velocity was also less, and the irregularities were greater than with black powder, as might be expected from what the author has already stated. The fact, however, remains that both in the case of the rifle and sporting gun practice good velocities were obtained with greatly reduced charges of hengstite.

In the experiments for penetration with shot, the results followed in about the same ratio as those relating to velocity and recoil in the last case, but they would doubtless have given about the same average as black powder with a slightly increased charge. As regards smokelessness, flamelessness, non-heating, and non-fouling with hengstite, the author found the claims to be practically substantiated. Smoke there was none, only a puff of light vapor (carbonic gas), which rapidly condensed and disappeared from sight. Flame there was none, so far as the eye could detect in a darkened rifle range, only a faint pale blue glow being visible at each discharge. Fouling there was none in the ordinary sense of the word, while a number of rounds fired in rapid succession failed to do more than warm the barrel. An equal number of rounds of black powder similarly fired from the same rifle, cold, heated it considerably. As regards the nature of the report, in every case there was distinctly less noise with hengstite than with black powder. As a practical result hengstite may be said to possess, weight for weight, about 150 per cent. greater strength than gunpowder. Another important point is that it is not liable to be exploded by concussion.

The author's experiments with hengstite as a blasting agent were carried out in the underground workings of the Morgan Gold Mines at Dolgelly. The locality of the shots was the stope on the south lode, the ground being hard, gold-bearing quartz rock. The boreholes were all 1¾ inch diameter, with an average depth of 2 feet 4 inches. Blasting gelatine is the explosive used in this mine, and in one hole the charge would have been 8 oz. of that compound. Here a charge of 6½ oz. of hengstite was used, not in the compressed but in the fibrous condition, for there was none in the compressed form available for the purpose. Notwithstanding this disadvantage, the shot brought down a large quantity of rock, and cracked and loosened the face of the working over a large area. It was affirmed by Captain Clemo, the captain of the mine, who charged all the holes himself, that the 6½ oz. of hengstite did more work than would have been accomplished with the 8 oz. of blasting gelatine. In the other cases the charges of hengstite used corresponded in weight with the charges of blasting gelatine which would have been used in the various boreholes. In every instance more work was done, that is, more ground was got, and a greater area of the face was loosened by hengstite than would have been got and loosened by blasting gelatine. In order to account for this superiority, the author would point out that the explosion of blasting gelatine is exceedingly rapid, and its effects are therefore of an intensely local and smashing character. In hengstite the explosion is slightly retarded, and its effects are therefore more distributed, the result being a lifting and rending instead of a local smashing action. Although the shots were fired in close workings, the author could detect no noxious fumes whatever on returning to where the shots had been fired. The charges were fired by means of an ordinary naked mining fuse, detonators not being required, which is an advantage both in point of safety and working cost. Although hengstite was tried under manifest disadvantages in being only hand made, and, in the mining tests, in not being in the proper form for that purpose, the author considers the results most satisfactory.

TONITE.

The last explosive for notice with which the author is acquainted, by reason of his having been present at experiments made with it, is tonite. The history of tonite extends back to 1870, in which year Mr. Robert Punshon first carried out some experiments with his gun-cotton, which consisted of ordinary gun-cotton soaked in a solution of sugar and mixed with niter, in order to regulate its rapidity of explosion. This explosive was subsequently improved upon, and in April, 1870, the author witnessed some experiments with it at Wimbledon, where it was successfully tried in rifle practice.

The author is not aware that this explosive ever went beyond experiment in connection with small arms. In time, however, Punshon's gun-cotton was improved into what became known as cotton powder, the improvements being due to Messrs. Mackie, Faure & Trench, who mixed gun-cotton with nitrate of baryta. The manufacture of cotton powder was started by the Cotton Powder Company, who constructed works at Faversham, where, in February, 1875, the author witnessed some satisfactory experiments with this compound.

In time the name of tonite was given to this explosive, which is simply a nitrated gun-cotton, the nitrate usually employed being that of barium. Potentite is another variety of tonite, in which nitrate of potash is used in place of nitrate of baryta. This latter explosive is also manufactured by the Cotton Powder Company at works at Melling, near Liverpool. The author believes that both tonite and potentite are still in use, although a letter written by him to the secretary of the company asking for information has failed to elicit an acknowledgment.

ROMITE.

In the early part of this paper the author stated his intention of confining himself to a notice of those explosives which he had been professionally engaged upon or had witnessed experiments with. He thinks, however, the paper would hardly be complete without a reference to a few high explosives which have incidentally come under his notice from time to time, but of which he has had no practical experience.

The first of these is romite, which is the invention of Herr S. Joberg, a Swedish engineer, and consists of a mixture of nitrate of ammonia with naphthaline or nitro-naphthaline. When required for use this preparation is mixed with chloride of potash. The advantages claimed are safety in transport and the production of a powerful explosive at the moment of use only.

Some comparative experiments made with romite and dynamite in the autumn of last year went to show that romite was only about half as powerful as dynamite. This conclusion, however, the manufacturer of romite not unnaturally refused to accept.

MELINITE.

During last year melinite came prominently into notice in connection with experiments which were made with it by the French government. Its composition is kept secret, but it is believed to be an improvement upon an explosive invented by Mr. Turpin in 1885, and which consists of picric acid combined with other substances.

The explosive force of melinite is stated to be about three times that of gunpowder, and this appears to be confirmed by the results of the French experiments. The author has recently heard that another substance called cresilite is now added to melinite, which is said to materially increase its power and safety in handling, as well as to contribute to its stability. Cresilite is said to be a hard, gummy composition, which is melted in copper vessels and poured into the shells which are to be charged with melinite. The process of charging shells with melinite—for which purpose it appears to be mainly used—is stated to be a delicate and dangerous operation.

EMMENSITE.

Emmensite is the invention of Dr. Emmens, and is prepared by dissolving at a moderate temperature an excess of picric acid in nitric acid of a density of from 50° to 60° Baume; an operation which can be performed without danger if the temperature is kept low. On evaporating the liquid afterward, fine rhombic crystals of a bright yellow color are first deposited, which are followed by others of a lighter hue, and finally by a precipitate of a light gray color. The crystals forming this precipitate contain more hydrogen than picric acid, but the oxygen is insufficient for complete combustion. To provide this missing quantity, Dr. Emmens employs ammonium nitrate, the mixture being effected by melting together five parts by weight of the above crystals with five parts of ammonium nitrate over a paraffin bath. When completely fused, six parts of picric acid are added and thoroughly incorporated, after which the whole is poured out into moulds. These operations involve no danger if the temperature is kept below 200° C. Thus prepared, emmensite is an amorphous solid of a bright yellow color, completely odorless, but having a bitter taste. It has a spongy texture, and its specific gravity is 1·7. It is made in several degrees of strength, some of the qualities resembling dynamite, while others can be used for firearms. It is but slightly sensitive to shock, and one variety can be heated without exploding.

GRAYDONITE.

Graydonite is the invention of Lieutenant James Weir Graydon, late of the United States navy, who is the inventor of the dynamite shell bearing his name. Mr. Graydon claims for graydonite absolute freedom from danger in handling and transportation, a destructive power of from 400 to 700 per cent. greater than that of No. 1 dynamite, and suitability for military and naval uses. Particulars of its composition have not been made public.

PRACTICAL WORK.

Besides the experimental trials and practical work done by the author with some of the explosives described, as stated in connection with them, he has also made a few heavy blasts, a reference to which may prove useful. In the same way the author thinks a notice of some of the more important blasting operations is also desirable in connection with the present subject, and this notwithstanding that he touched upon these points in his inaugural address in 1886. He has made several heavy blasts with lithofracteur, having several times exploded 50 lb. charges under water, under temporary bridges, and against military defenses, in demonstrating its suitability for subaqueous mines and for other military purposes.

At the Quenast Quarries in Belgium, in 1872, the author, in conjunction with Mr. Engels, brought down in about an hour a heavy masonry road bridge which it was desired to remove, lithofracteur being the explosive used. The heaviest blast effected by the author was with 115 lb. of lithofracteur. This was carried out at the Jersey harbor works, where Sir John Coode desired to remove among other obstructions a wall of rock which was standing out from the main rock, but running in a line with its face, there being a space of a few feet between the two. This wall was about 20 feet high, 19 feet long, and 12 feet thick, the foot being exposed for a short time only at low water and the rock being nearly covered at high water, ordinary tides, thus affording the advantage of the resistance of a good head of water for tamping.

At low tide the author planted the 115 lb. charge in the angle formed by the wall and the main rock, with the capped fuse inserted, which was led up to the top of the rock. At high water, which happened to be at midnight, he rowed out, landed, lighted the fuse, rowed away, and in a short time heard the low rumble of the subaqueous explosion and the tumbling of the water. The next low tide revealed the wall of rock reduced to fragments and lying on the bottom, the explosion having also acted in a downward direction. It was computed by the engineer of the works and the author that at least 400 tons of rock had been dislodged by the blast. This gave about 3½ tons per lb. of explosive used, which may be taken as a fair average of what it should do on a large scale. The author also did some blasting work for Sir John Coode at the Douglas harbor works, Isle of Man.

Another subaqueous blast of a very different character from the preceding was carried out by the author in December last year with carbo-dynamite. Messrs. Le Grand & Sutcliff having sunk one of their artesian tube wells nearly 500 feet, without obtaining the anticipated supply of water, consulted the author as to the desirability of exploding a charge about 400 feet down the bore, with a view of opening up the fissures in the chalk. The author advised the blast to be made, and was commissioned to carry it out. The boring is situated on land adjoining the Grand Junction Water Works Co.'s works at Ealing, on the border of the Brent Valley, and the bore was put down for the company's engineer, Mr. Alexander Fraser. The borehole was 470 feet deep from surface and 4¾ inches in diameter. It was tubed to a depth of 326 feet, and the water level stood at 50 feet from surface. To avoid injury to the tube, and to get well into the chalk, which was very hard and compact, the shot was fired at 400 feet from surface, thus giving a head of 350 feet of water over the charge, being equal to a pressure of about 150 lb. per square inch. From his experience of carbo-dynamite the author selected that explosive for his shot—in the details of which he was ably assisted by Mr. Reid.

The charge was inclosed in a lead torpedo, and was fired by submarine safety fuse and a detonator. The fuse was timed to burn at the rate of one foot per minute, and the author employed 6 feet of fuse. The lowering of the torpedo occupied two minutes, which allowed four minutes for the fuse to burn after the torpedo had reached a state of rest and before exploding the charge. At the end of 3½ minutes, however, the wire rope to which the torpedo was attached gave a rebound, and the water in the borehole was heard to be in a state of violent agitation, the explosion having taken place.

The author attributes the fact of the charge being exploded 2½ minutes before its time to the action of the fuse being accelerated by the heavy head of water over it. He mentions the circumstance as a hint to others always to be well within the limit of safety as regards length of fuse. The blast proved a success so far as the work of chambering the chalk was concerned, as large quantities of debris were subsequently pumped up. The water supply, however, was not sensibly increased, and the conclusion is that the chalk at the point is a hard, solid mass, untraversed by any fissures.

HEAVY GUNPOWDER BLASTS.

There are two cases of heavy blasting with gunpowder to which the author may here refer. The first of these was the removal of the Rounddown Cliff at Dover in 1843, in which operation 18,500 lb., or 9¼ tons, of gunpowder were disposed in three separate charges which were fired simultaneously by a voltaic battery. The second case was at Holyhead, when the harbor was being made. One of the heaviest blasts there was 12,000 lb., or 6 tons, of gunpowder, divided up into several charges and ignited simultaneously by means of a platinum wire heated by a Grove battery. The total quantity of rock stated to have been removed by this blast was 40,000 tons, or 3·35 tons per pound of explosive.

In the autumn of 1879 the author witnessed two heavy blasts with gunpowder at some granite quarries on the western shores of Loch Fyne, near Inverary. The first of these blasts was effected with 3 tons of gunpowder at the Crarae quarry, which is about eight miles from Inverary, and the second with 5 tons at the Furnace quarry, which is some two miles nearer that town. The quarries present extensive faces, and it is mainly the faces which are brought down, the powder being disposed in galleries to the rear of the face and as near as possible to the dividing joints of the rock. The mines were fired by electricity, the 3 tons of powder in the Crarae quarry bringing down an estimated aggregate of about 60,000 tons of granite, and the 5 tons at Furnace about 100,000 tons. This gives in each case 10 tons of rock per pound of powder, but it is to be observed that the conditions of work were comparatively easy, the face only requiring a forward heave to detach and throw it down on to the floor of the quarry below.

HEAVY DYNAMITE BLASTS.

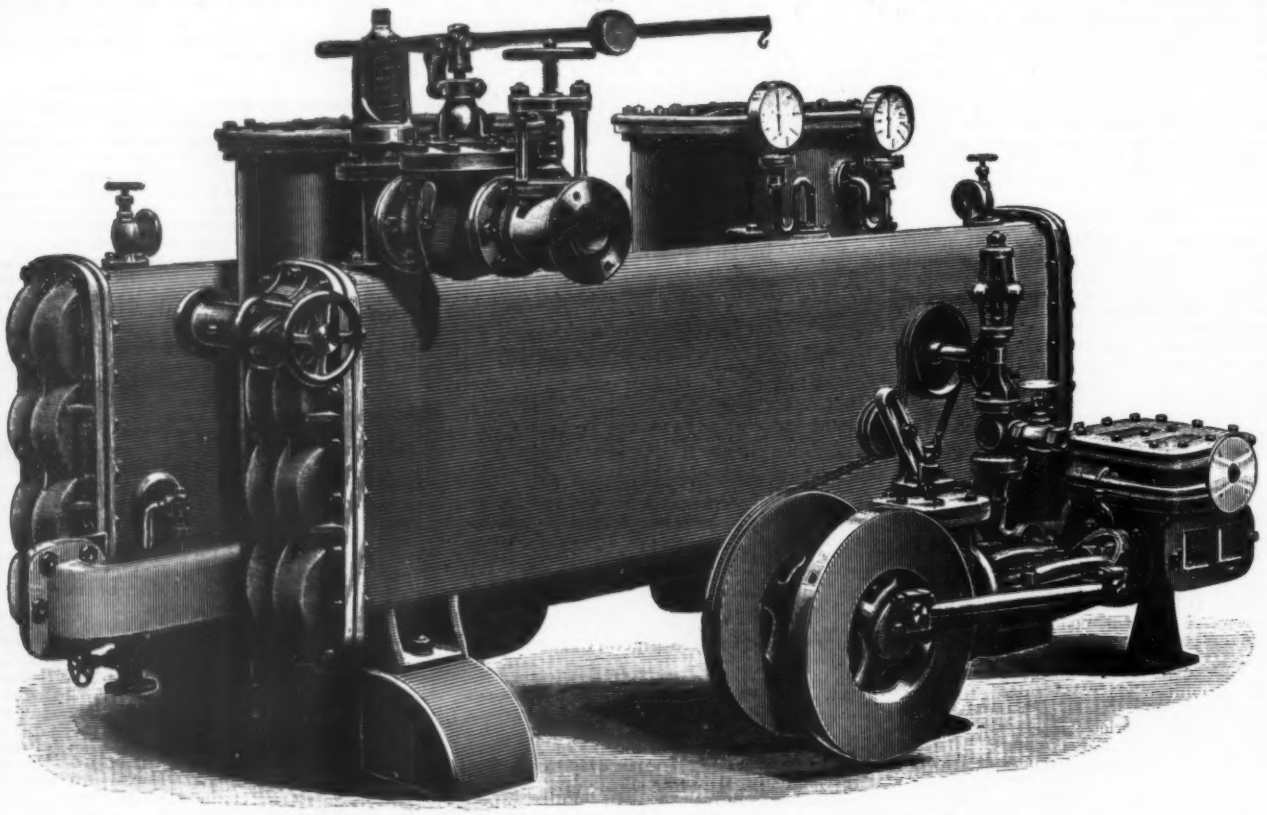
In the early part of 1885 a considerable blast was effected with dynamite in a stone quarry at San Francisco. Four galleries were driven each 50 feet into the rock, and were returned at the end at right angles, forming a letter L. The explosive, of which 5½ tons were employed, was placed in the return galleries, the charges being tamped with debris. The four explosions were arranged to occur successively, the first to loosen the rock and make the work of the next easier, and so on with the second and third. It was estimated that the 11,000 lb. of explosive had displaced 35,000 tons of rock, being a little over 3 tons per lb., and thus practically agreeing with the author's experience.

The heaviest blast, however, was that which was successfully accomplished in the autumn of 1885, at the entrance to East River, New York, known as Hell Gate, when 150 tons of nitro-glycerine compounds were exploded simultaneously in removing Flood Rock. Nine years previously, namely, in September, 1876, the most extensive blasting operation up to that date was successfully accomplished in the demolition of Hallett's Reef at the same place. The area then operated upon was three acres, and the weight of nitro-glycerine preparations (chiefly dynamite) used was about 25 tons, the quantity of rock demolished being estimated at over 63,000 cubic yards. Assuming the rock to weigh 2 tons to the cubic yard (that was the weight of the rock in Jersey), we have 126,000 tons rock removed by 50,000 lb. of explosive, or rather less than 3 tons per pound. After the removal of Hallett's Reef, operations were carried on at Flood Rock on the opposite side with a view to its removal, and by this means to render safe the navigation of the channel. On October 11, 1885, this object was successfully accomplished by the aid of over 150 tons of explosives, which is six times as much as was used on Hallett's Reef, and which constitutes the biggest blasting operation on record.

In this case nine acres of rock were honeycombed, and charged with 75,000 lb. of No. 1 dynamite and 240,000 lb. of rackarock, which is one of the potash class of explosives. The nine acres of rock had been pierced from below with four miles of tunneling in galleries, the floors of which were from 50 to 64 feet below mean low tide, with walls of from 10 to 24 feet thickness between them, and supported by 467 columns of rock, each 15 feet square. In the columns and rock roof of these galleries nearly 14,000 holes, of an average depth of 9 feet, had been drilled, and each was charged with a 6 lb. cartridge of rackarock and a 3 lb. cartridge of dynamite. These were all connected by a battery, so as to be exploded by a single electric spark. The shock of the explosion lasted about forty seconds, the visible results being the raising of an enormous volume of water to a height of 200 feet into the air. Upon subsiding, it developed a mass of broken rock, from which fire issued for a short time; but in two minutes more everything was quiet. No damage was occasioned to property, although a tremor caused by the explosion was felt at some distance. An examination of the rock showed that the explosion had been completely successful.

CONCLUSION.

From what the author has stated, it will be seen that there are several high explosives of good repute ready to hand for present use, with others promising their aid in the near future. In selecting an explosive various considerations arise, for no single explosive at the present time appears to be suited to every class of ground. The one, however, which possesses to the greatest extent the important attribute of general adaptability will as a matter of course—other things being equal—take the lead. It is to this feature of modification to suit varying conditions that manufacturers and inventors are now largely addressing themselves. The leading points for consideration in selecting a blasting agent have reference to the character of the ground to be worked; that is to say, whether it is hard or soft, tough or friable, compact or fissured, damp or dry. And when the selection has been made, the explosive should be carefully tried before it is either adopted or rejected. No hard and fast rule can be laid down in the selection of an explosive, but it may be taken for granted that when a miner gets an explosive that suits his ground as well as his pocket, he will hold on to it very tenaciously. Explosives, like most other mundane things, will be found to be amenable to that immutable law which governs the survival of the fittest.



IMPROVED WATER DISTILLING APPARATUS.

IMPROVED WATER DISTILLING APPARATUS.

WITH the increase of pressure in marine boilers the use of non-saline feed water has become an absolute necessity, and although, theoretically, fresh feed water is provided by the employment of surface condensers, in practice the supply of feed water from this source alone is always less than the quantity of water evaporated by the boiler, as a certain amount of waste is unavoidable. If this waste be made up by sea water, the boiler is liable to incrustation, and it has therefore been found necessary to fit special distilling apparatus to provide the few tons of fresh water which are daily required to keep down the salinity of the water in the boilers.

In the ordinary form of distillers, a comparatively large quantity of water is simply boiled down, and the vapors condensed. By this means the trouble of incrustation in the boilers is avoided, but the evil is transferred to the distilling apparatus, the heating surfaces of which, by reason of scale deposits, very soon lose their original efficiency. In the Yaryan apparatus, which we illustrate, this difficulty has been overcome in a most ingenious manner, by the introduction of a new principle in the evaporation of liquids. Instead of boiling the water in the ordinary sense of the word, the inventor arranges for its continuous evaporation in small quantities, by injecting it in the form of a finely divided spray into tubes, which are on the outside surrounded and heated by steam. The principle here involved is that of film evaporation, as opposed to the evaporation in bulk.

It will be easily seen that in the ordinary way of evaporating a liquid, each time that a gas bubble is formed on the surface of the heated metal, it displaces a corresponding volume of the liquid, and the latter can only again come in contact with the plate after the bubble has been detached. Now, by blowing a spray of liquid at high velocity through a heated tube, the film of liquid is constantly passing over new portions of the heating surface, and the result is that the latter is utilized in a very much better way than when covered with a thick stratum of liquid. The inventor claims that by the adoption of this principle of film evaporation, the weight of water which can be evaporated per square foot of heating surface is more than twice as great as in the ordinary arrangement.

The Yaryan evaporator and distiller is, however, only one application of the principle of film evaporation. It has been applied to a great number of other purposes, including the concentration of solutions of sugar, glue, etc.; but we confine ourselves in the present description to the apparatus as made for use on board ship. It is made in several types, either for single, double, treble, or quadruple effect. Our illustration represents an apparatus for double effect, which is capable of yielding 20 tons of fresh water per day. The principle of multiple effect in evaporating apparatus is, of course, not new; but it has been carried out by Mr. Yaryan in an exceedingly practical and simple manner.

Each evaporator contains horizontal rows of steel tubes inclosed in a cast iron casing. The sea water is injected into the top row of tubes in the first evaporator through a series of nozzles, and passes successively backward and forward through the lower rows of tubes. The casing of the first evaporator is supplied with steam, which is preferably taken from the receiver between the intermediate and low pressure cylinders of the main engines. This steam condenses in the outer vessel, and the condensed water is carried off into the main condenser of the engine. The sea water, in passing through the inside of the tubes, is partly evaporated, and the mixture, containing about 25 per cent. of steam, passes into one of the vertical vessels seen in our illustration, between the two horizontal evaporators. There a separation between the vapor and liquid is effected by means of an ingenious arrangement of baffle plates, the vapor being passed on into the second evaporator, where it acts as a heating agent, and is in its turn condensed; while the liquid is passed through the inside of the tubes in the second evaporator, and is there further concentrated, another 25 per cent. of the original quantity being sent in the shape of vapor into the second vertical vessel, and there similarly condensed. In this manner, about 50 per cent. of the weight of sea water sent into the apparatus is ultimately obtained in the form of fresh water, which flows into the condenser of the main engines. It will thus be seen that the evaporation of the liquid takes place in a partial vacuum, and where a condenser is not available a small vacuum pump, of the type shown in our illustration, may be fitted to the apparatus. If the amount thus obtained is in ex-

cess of the requirements, a portion of it may be diverted into a separate fresh water condenser, and used as drinking water.—*Industries.*

EXHIBITS AT THE ROYAL SOCIETY.

THE following is a list of the principal exhibits at the conversazione on May 8, 1889.

The Tintometer.—Invented and exhibited by Mr. J. W. LOVIBOND, of Salisbury.

An instrument for matching, measuring, and recording the tints and hues of colored solids and liquids available for Eggertz's and Nessler's tests, valuation of pigments, standardizing colored solution, etc.

The comparison of the colored substances under examination with the standard tints and hues is made by means of an extensive series of accurately graded glass slips of different hues and strengths of color.

Portable Cavendish Apparatus for Demonstrating the Attraction of Gravitation.—Exhibited by Mr. C. V. BOYS, A.R.S.M., F.R.S.

This apparatus differs only from the well-known apparatus of Cavendish in matters of detail. First, instead of the beam six feet long carrying heavy weights, used by Cavendish, or half a meter long, used by Cornu, the beam consists of a piece of lead only one centimeter long, and this is inclosed in a round tube of metal, outside which the attracting weights are placed. This reduction of size has been rendered possible by the use of quartz threads, the production of which was shown two years ago. The advantages gained by the reduced dimensions are increased sensibility and almost perfect elimination of temperature disturbances. The particular apparatus exhibited is designed to show the effect, and that it is the same from time to time, rather than to determine the constant of gravitation absolutely. By arranging the two attracting weights and the two ends of the attracted body at different levels, the deflection is nearly double.

Experiment Showing the Insulation of Quartz.—Exhibited by Mr. C. V. BOYS, A.R.S.M., F.R.S.

A pair of gold leaves are supported by a short rod of quartz which has been melted and drawn out about three-quarters of an inch. The atmosphere is kept moist by a dish of water. Under these circumstances a glass insulating stem allows all the charge to escape in a second or two. With the quartz, but little change is observed in four or five hours. The quartz may be dipped in water and put back in its place with the water upon it. It insulates apparently as well as before.

Apparatus for Testing the Elasticity of Fibers.—Exhibited by Mr. C. V. BOYS, A.R.S.M., F.R.S.

One of these pieces of apparatus consists of a microscope cathetometer arranged vertically and a gravity bob which is deflected by the vertical pull of the fiber on a side arm. The lower end of the fiber is made fast to a beam carried by the microscope. A scale, to which the upper end of the fiber is fixed, is viewed by the microscope, which thus shows the stretch of the thread; the pulling force is found by subtracting the stretch from the vertical movement of the microscope, and multiplying by a constant previously found. The second piece of apparatus is used to measure the fatigue of fibers after torsion.

Fractures from Casting and Forgings of Manganese Steel, containing from 10 per cent. to 36 per cent. Mn, Illustrating the Influence of Different Combinations of Iron and Manganese.—Exhibited by Mr. R. A. HADFIELD.

When the manganese exceeds about 12 per cent., notwithstanding the large percentage of iron present, the material is found practically non-magnetic.

Photographic Map of the Normal Solar Spectrum (Second Series) made by Professor Rowland.—Exhibited by Mr. WILLIAM CROOKES, F.R.S., V.P.C.S.

Nine plates of the solar spectrum, wave length 3,270 to 6,950. Each plate contains two strips, three feet long.

The spectrum has been projected from concave gratings, of six inches diameter and 21½ feet radius, ruled with 10,000 or 20,000 lines to the inch, giving definition hitherto undreamed of. The scale is placed within 1-20th Angstrom division, or 1-100,000th wave length of its true position.

There are few instruments which will show more of the spectrum than can be found on this map, even below the line D, for the first line in B is shown widely triple. The original negative shows E, and even finer lines, like that at wave lengths 5276·1 and 5914·3, plainly double. As to other maps of the spectrum made by measurement and drawing, it may be said that no comparison is possible. The photograph is the work of the sunlight itself, and the user of this map has the solar spectrum itself before him, and not a distorted drawing full of errors of wave length and of intensity. The superiority is so great that there is no possibility of comparison.

In addition to the nine plates above described, there are exhibited two plates, each 2 ft. 10 in. long, of the B and D lines. The D lines are three inches apart, and the B group has an extent of about twenty-four inches.

Pitkin and Niblett's Fire Damp Meter.—Exhibited by Mr. JAMES PITKIN.

By means of these instruments it is possible to detect and estimate the percentage of oxygen or hydrogen in mixtures of these gases.

In its simplest form it consists of two ordinary cylindrical-bulbed mercurial thermometers. These are mounted on a suitable base, and are then graduated off in the ordinary way to the Fahr. or Cent. scale. One tube registers the temperature of the mixed gases. The other, which is the gas indicator, has its bulb coated with one of those metals which, when in a very finely divided state, has that peculiar property of occluding and facilitating the chemical combination of certain gases. When placed in a gaseous mixture, and during the combination of the gases due to the above property of the metal, a considerable amount of heat is developed. The heat generated thus produces a corresponding rise in the mercurial column. To read the instrument, the difference between the two-scale reading is taken, and then by comparison with a table supplied with each instrument, the percentage of gas may be read off.

In the case of fire damp and air, or coal gas and air, the amount of heat developed appears to correspond approximately to the explosive activity of the mixed gases. A sliding scale may be fixed on the instrument, which can be graduated in terms of percentages of any particular gas.

Combustion in Dried Oxygen.—Exhibited by Mr. H. BRERETON BAKER, M.A., Dulwich College.

(1) Charcoal is heated to redness in dried oxygen without any visible combustion. The oxygen has been in contact with the drying agent for two months.

(2) Sulphur is distilled in oxygen dried by phosphorus pentoxide for five years. No flame is seen. In moist oxygen sulphur burns at a temperature of 320°, its boiling point is 440°.

(3) Phosphorus is distilled in oxygen dried in the same way. It boils at 290°. In moist oxygen it catches fire at about 60°.

(4) Ordinary phosphorus is not luminous at any pressure in dried oxygen. The tube on the right contains ordinary phosphorus in moist oxygen. If the corresponding mercury reservoir be lowered, the pressure in the tube will diminish, and the phosphorus will become luminous. The tube on the left contains phosphorus which has been carefully purified in oxygen which has been dried by contact with phosphorus pentoxide for four months. By lowering the mercury reservoir on the left, the pressure will be diminished in this tube, but no luminosity will appear. Phosphorus is thus proved not to undergo slow combustion in oxygen at a low pressure, if the oxygen be sufficiently dried. In these experiments the substances must not only be freed from moisture, but also from any traces of hydrogen, which, by its union with oxygen, would produce water. Before they are filled, the glass tubes are heated nearly to their melting point, to free the glass from adhering moisture.

(5) Amorphous phosphorus is heated in a tube containing pure nitrogen in the vapor of boiling mercury (360°), without undergoing the change to the ordinary modification.

Amorphous phosphorus has been regarded as being incapable of undergoing true conbustion. If heated to 260° in air or oxygen it burns, but it is generally supposed that this combustion is preceded by a change to ordinary phosphorus, which burns readily at this temperature. The experiment of heating the amorphous phosphorus in nitrogen proves that it does not change if it is heated in a neutral gas, and therefore that the combustion in oxygen is a true one, and is not necessarily preceded by a transformation to the ordinary modification.

An Experiment Showing an Effect of Light in Magnetizing Iron.—Exhibited by Mr. SHELFORD BIDWELL, M.A., F.R.S.

A bar of iron which has undergone certain preliminary treatment is placed close to a small reflecting magnetometer. When the iron is illuminated by an oxyhydrogen lamp, it instantly reflects the magnetometer needle, as is evidenced by the movement of the spot of light upon the scale: and when the illumination is cut off, the spot of light at once goes back.

The preparation of the iron consists in first magnetizing it by a current of electricity passed through a surrounding coil, and then very perfectly demagnetizing it by a reversed current of suitable strength. Its magnetic condition is thus rendered unstable, and its susceptibility appears to be greater for a small magnetizing force acting in the same direction as that by which the bar was at first magnetized, than for an equal small force in the opposite direction.

For further details see *Roy. Soc. Proc.*, vol. xlv., p. 453, 1889.

Preparations of the New Element Gnomium, recently Discovered by Gerhard Kruss and F. W. Schmidt, of Munich.—Exhibited by Dr. HUGO MULLER, F.R.S.

Gnomium oxide.

Gnomium chloride (in aqueous solution).

Nickel from which the gnomium, which, up to the present, always accompanied it, has been separated.

Nickel oxide free from gnomium.

Gnomium is a metallic metal which, according to the discovery of Kruss and Schmidt, is always associated with cobalt and nickel, and consequently neither of these metals has up to the present been known in the pure state.

Hollow Cylinder and Sphere used in the Redetermination of the Weight of a Cubic Inch of Distilled Water, 1889.—Exhibited by Mr. H. J. CHANEY.

t=62°, B=30 inches. One cubic inch=252·286 grains.

Voltaic Balance.—Exhibited by Dr. G. GORE, F.R.S.

Used for measuring voltaic energy in chemical analysis; strength of aqueous solutions; detecting chemical changes in liquids and measuring their rates; detecting chemical compounds and their combining proportions; measuring losses of voltaic energy during chemical combination; measuring chemical energy.

By means of it the influence of 1 part by weight of chlorine in 500,000 million parts by weight of water has been detected.—*Chemical News.*

HEINRICH GUSTAV REICHENBACH.

ON the 6th inst. there died at Hamburg, in the sixty-seventh year of his age, a botanist long and familiarly known to his English colleagues, and one whose name will be preserved in the annals of botany.

Heinrich Gustav Reichenbach had been Professor of Botany and Director of the Botanic Garden at Hamburg since 1862. He was born in Leipzig, his father having been also a well-known botanist and professor in Dresden from 1820 till his death in 1879. Much of the younger Reichenbach's work was done in association with his father, with whom he co-operated in the production of the later volumes of the carefully elaborated *Icones Floræ Germanicæ et Helveticæ*. But work of this character, carefully and critically executed though it was, was cast into the shade by the magnitude of his labors among the Orchidaceæ. Reichenbach the younger devoted more than forty years of his life almost (though, as we have seen, not quite) exclusively to the study of orchids.

At the commencement of his career, Lindley was still in the plenitude of his powers, but when, some quarter of a century since, the great English botanist failed in health, and subsequently died, there was no one to question the supremacy of Reichenbach so far as orchids were concerned.

From that time to the present the Hamburg professor has reigned with undisputed sway. His reign corresponds in its progress with the development of that passion for the cultivation of orchids which has attained such large proportions in this country. This is a fashion which at present shows no sign of waning here, while it is spreading widely in other countries. It has proved of signal service to orchidology in its systematic aspect, and to a less degree to morphology and biology, as witness, to cite only one illustration, the work of Darwin on the "Fertilization of Orchids." A hundred years ago about three hundred species were catalogued in the later editions of Linnæus' "Species Plantarum," and those three hundred were very imperfectly known or illustrated. About sixty years have elapsed since Lindley began his first systematic enumeration of the genera and species, a work in which he was at first greatly aided by the previous labors of Brown and by the splendid drawings of Bauer. In 1840, at the conclusion of the "Genera and Species," Lindley mentions that the total number of species included in that work amounted to 1,980, of which the author himself had analyzed three-fourths. Later estimates in the "Vegetable Kingdom" bring the numbers up to 394 genera and 3,000 species. Bentham, in 1883, calculated the known species as between 4,500 and 5,000; while Pfitzer, the most recent census-maker, gives the extreme number of species as 10,000. Granting that this latter figure is excessive, it at least suffices to illustrate the enormous increase in our knowledge of orchids. This advance has been, as we have said, chiefly due to the orchidomania which originated as a consequence of the exhibition of a few remarkable forms at the early meetings of the Horticultural Society, and which has been growing ever since. We never heard of any material good arising from the tulipomania; but the passion for orchids, involving, as it has done, the exploration of the countries where they grow, and the collection and transmission of countless thousands of specimens, live and dead, not only of orchids but of plants of other orders also, has most undoubtedly been of great service to botany, and it has served also to illustrate the great, but often unappreciated, value of gardens as instruments of scientific research. Dried specimens of orchids afford a sorry spectacle at best, and the characters upon which the distinction of genera and species depend are readily obliterated or lost in the drying process. But in gardens the material is often ample, and in the best condition for examination.

Reichenbach, as we have seen, was able to avail himself to a much larger extent than any of his predecessors of the facilities offered by gardens. He became the acknowledged referee on all questions of nomenclature, and to him were constantly submitted fresh specimens for examination. Of late years, also, hybridization has been practiced to a large extent among orchids, and the resultant hybrids found their way to Hamburg; there to be compared with the parental forms from which they had emanated. The result of this correspondence with the orchid growers of all classes in all countries, as well as with collectors and botanists, was that the Hamburg professor became the depositary of the greatest amount of orchid lore yet accumulated and the possessor of the largest stores of materials relating to the order. Unhappily his synthetic faculty was by no means so strong as his acquisitive tendencies were great and as his analytical powers were developed; so that much is left for his successors to accomplish in collating and expounding his work. In no place in the world can this be done so readily as at Kew, so that on all accounts it is earnestly to be hoped that the late professor's herbarium and notes may find their way to that establishment, where Lindley's collections are already enshrined.

Reichenbach was almost exclusively a systematist. He had little to say on morphological questions, and less on the biological points which lend such great interest to the study of the order. Speculations were made the subject of sarcasm by him, and to the last it may be doubted whether he had any great amount of sympathy with those researches which have furnished the clew to the explanation of the extraordinary and highly diversified structure of orchid flowers and illustrated alike its genetic and its physiological significance. Nevertheless, as in his lifetime he was constantly and disinterestedly at the service alike of his brother naturalists and of the orchid-growing community, shrinking from no labor or trouble where an orchid was concerned, so in that future reconstruction of the order on morphological and physiological principles which is inevitable, the botanist, be he who he may, will find himself as much indebted to the labors of Reichenbach, as unable to proceed without constant reference to them, as are the students of the present day. His title to our gratitude is indefeasible; it will be even more so to our successors.—*Nature.*

CHARLES GEORGE GORDON.

THIS statue was voted by the House of Commons in the autumn of 1885, and the work of executing it was intrusted by Mr. Plunkett, the First Commissioner of Works, to Mr. Hamo Thornycroft. There was no competition. The site ultimately chosen for the memorial is midway between the fountains. The total height of the monument is 29 feet. The statue, which is in bronze, is 10 feet 6 inches high. On the sides of the shaft of the pedestal are two bronze panels—allegories—"Charity and Justice" and "Fortitude and Faith." Gordon is represented as a staff officer, wearing a patrol jacket. His head is slightly inclined forward, resting at the chin on his right hand; his Bible he firmly grasps with his left. He carries no sword or weapon, only the famous short rattan cane, often called during his China campaign his "Wand of Victory." Standing firmly on his right foot, his left is raised on a broken cannon. This action is intended to symbolize his moral attitude as a soldier. Although he hated war and bloodshed, he seemed bound by fate to be ever fighting.

The statue was cast by Mr. Moore, of Thames Ditton, and the pedestal was wrought by Messrs. Farmer & Brindley.

We are indebted to the *London Graphic* for our engraving.

Charles George Gordon was born in England in 1833; was lieutenant of engineers in 1852; served in the Crimean war, and was wounded at Sebastopol. After peace was concluded he was employed in surveying and settling the Turkish and Russian frontiers in Asia. He was then engaged in an expedition against Pekin, and, after all the objections raised by the Chinese government had been satisfied, he remained in the Chinese service. At the close of 1861 he made a journey from Pekin to the Chotow and Kalgan passes on the great wall, passing Tiayuen, a city never before

STATUE TO CHARLES GEORGE GORDON.

visited by Europeans. In 1863 he was appointed commander of what was afterward known as the "Ever Victorious Army," and was mainly instrumental in suppressing the Tai-Ping rebellion in that and the succeeding year. He found the richest and most fertile districts of China in the hands of the most savage brigands. The silk districts were the scenes of riot and great cruelty, and the great cities of Hangchow and Soochow were fast being reduced to ruin. Gordon relieved the great cities, dispersed the rebel forces and confined them to a few tracts of devastated country. For these exploits he has since been well known under the name of "Chinese" Gordon. He was promoted to the rank of captain in the English service in 1859, became major in 1862, and lieutenant-colonel in 1864. He was British vice-consul of the Delta of the Danube, Turkey, from 1871 to 1873, when he conducted an expedition into Africa under the auspices of the Khedive of Egypt, by whom he was appointed Governor of the Equatorial Lakes. Subsequently he was made a pasha, and in 1877 the Khedive appointed him governor of the whole of the Soudan, which position he retained until 1880. His administration presented many remarkable features. During his first year he traveled through the whole of the vast region committed to his rule, accommodating disputes, changing local officials, and exercising a justice and moderation which gained the love and admiration of the natives, while he went from place to place with a celerity of movement which almost excited superstition. He put down a revolt in Darfur, brought an end to a tedious war with Abyssinia, captured numerous slave caravans, but failed in his endeavors to establish permanently satisfactory arrangements between Egypt and Abyssinia. In 1880 he received an appointment as private secretary to the Marquis of Ripon, Governor-General of India, but resigned the post before entering on its duties and paid a flying visit to China. In 1881 he accepted the command of the Royal Engineers at the Maûritius, where his term of office expired with his attainment of the rank of major-general, and he was afterward prominently connected with the government of the Cape of Good Hope. He then undertook a mission to the Congo, under the auspices of the King of Belgium, his main object being the suppression of slavery, but before he could make any progress with this work a revolt broke out in his former government of the Soudan, headed by El Mahdi, or the "False Prophet," when Gordon was called on to go to Khartoum as the accredited representative of the British government in the Soudan. He is said to have had a firm conviction that in doing so he would not return alive. On his arrival at Khartoum, in the spring of 1884, his remarkable personal influence secured him a warm welcome, and he virtually became the temporary sovereign of the place and district. In the middle of March he took the field against the hostile Soudanese, but was unsuccessful in his first battle, owing to the treachery of two pashas, whom he at once sentenced to death. The capture of Berber by the rebels cut Gordon off from communication with Cairo, and early in April Khartoum was invested. Numbers of the population went over to the enemy, but Gordon, through vigorous personal efforts, succeeded in obtaining soldiers and supplies. He planted torpedoes in front of his lines, converted river steamers into iron-clads, and waged war so successfully that for a time he repelled the great besieging army. They returned, however, with re-enforcements, and on January 26, 1885, as a British army of relief under General Wolseley was within two days' march of the place, Khartoum was betrayed into the hands of the enemy by a traitor named Ferig Pasha, and Gordon was said to have been slain in the ensuing massacre. The event caused great sorrow in England and throughout almost the whole of the civilized world.

Gordon was not only a man of high moral character and irreproachable in his private life, but his religious convictions were so marked as to verge on superstition. The Queen sent to his sister a feeling letter of condolence, and the latter sent to the Queen a Bible which Gordon had carried on his person through many of his campaigns, which it is said the Queen holds among her dearest treasures. An offer was made to mark his death by a monument in Westminster Abbey, but this was declined in favor of a monument where he would have preferred to be interred, at his home.

KHARTOUM.

THE accompanying illustration represents the city chiefly memorable for its gallant defense by General Gordon. It is a town of Sennaar, the center of government of Egyptian Soudan, situated at the junction of

KHARTOUM ON THE NILE.

the Blue and White Nile; lat. 15° 36′ N., long. 32° 38′ E., and has a population now estimated at between 30,000 and 50,000. It is about 1,400 feet above the level of the sea, but the inundations of the White Nile frequently reach the wall by which it is surrounded. The houses formerly were mostly constructed of millet stalks, and scattered over a wide area, but the town had previous to its capture a considerable number of substantial modern buildings, the most imposing of which was the stone-faced palace of the governor. As the center of the great caravan routes from the interior of Africa, Khartoum has had a large trade, but the inhabitants have always shown a preference for the slave traffic when the governor has been indulgent or inefficient. There are extensive gardens and rows of date palms planted nearly half a century ago. Khartoum carries on an extensive ivory trade, and its merchants maintain a great number of settlements in districts as near as possible to the best ivory-producing localities, apportioning the surrounding country among themselves, after bringing the natives to a condition of vassalage. They are represented by agents who command the armed men of the country, determine what products the natives shall pay as tribute, appoint and displace the local managers, carry on war or make alliances with the chiefs, and once a year remit the collected stores to Khartoum. The town was formerly the seat of a Roman Catholic mission and of several Protestant missions, and several European consuls were stationed there, but since its capture by the Mahdi very little trustworthy information of its affairs has been obtainable.

THE RACES AT PARIS.

ANOTHER race has taken place, and one that was full of incident in various ways. First, the strike of the coachmen, who put an interrogation point upon the means of locomotion (but we hasten to say that there was scarcely any more trouble than usual in conciliating the favor of the knights of the whip), and then the shower which, at the precise moment at which the competitors came upon the track, threw the spectators into disorder, and, finally, the victory of Vasistas, an outsider, so extraordinary that 100 to 1 was put up on him at the start. What is that! *Vas ist das?* (Pardon the Teutonic pun.) This Vasistas, at all events, did not give much life to the pluggers, who did not take much stock in him. So the arrival of the victor at the starting point created no more enthusiasm than if Amerlio, the Italian champion, had triumphed. However, for many people, the race itself is of small consequence. The important thing is the view of the crowd, of the toilets, of the equipages, etc. As regards this, the people have never been better served. To assert that all these creations of the dressmaker and milliner were equally happy would be to stretch the truth too much. Let us cite, especially, a green, yellow, and rose-colored English toilet that would have set all the dogs of the United Kingdom howling with fright. Madam Carnot, who was much admired in her red and black toilet, gave especially an example of good taste. The gallery reserved for ladies, with its ultra *chic* corner, offered the purest specimens of Parisian elegance.

The Princess De Metternich wore a golden Chinese crepon; she bid her friends good-by, and announced that she was to start the next day for Alsace, and then would go to Vienna.

The Countess De Pourtales, in an elegant cream-colored toilet with Pompadour impressions, said (contrary to what the papers have published) that she had not sold her Robertsau domain, and that she would ere long go there to live.

The Countess De Saint-Roman, whose husband is part owner of Vasistas, was continually surrounded after the race.

The Baroness De Soubeyran, as if she had foreseen the defeat of Maypole, was clothed in a half-mourning costume of turtle-gray watered silk.

Upon the whole, creamy white prevailed. As for hats, fancy never gave itself freer play. There were enormous ones, and there were very small ones. "All kinds are good except the ugly kind." This habitude of the fashion is rational, however, for the same form does not become every face.

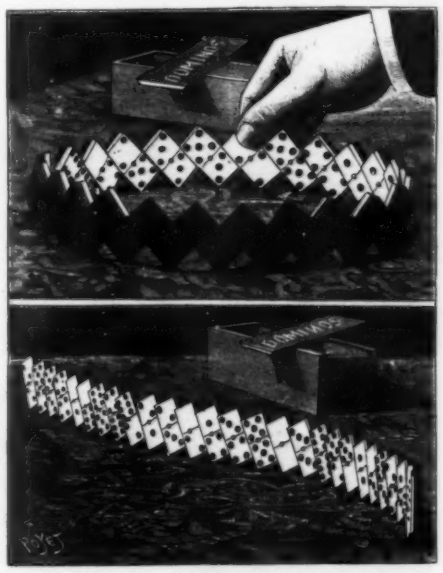
But the time to return has arrived, and we must think of nothing else than finding our carriage.

And, for next year, no more strike, no more rain, no more Vasistas! Let us hope so at least.—*Le Monde Illustré.*

EXPERIMENTS ON CENTER OF GRAVITY.

THE following experiments may be easily performed with the pieces of the game of dominoes.

Suppose we present this problem to our friends:



FIGS. 1 AND 2.—EXPERIMENTS WITH DOMINOES.

How shall we make all the pieces of a game of dominoes stand upon their points without the aid of any foreign object? Some will try pyramids, and others will try scaffoldings that will tumble down before half the pieces have been superposed. But the problem is mute on the subject of such superpositions, which, in fact, it is not necessary to seek. The trick is performed in a very simple manner. First, to form a circle, place one of the pieces on the table to serve as a support to the one which is to begin the row, and which rests on one of its points obliquely, against it. All the other pieces are placed in succession in the same way, their top on a level with the median line of the one that precedes, and all being curved around an imaginary center, but calculated in such a way as to form an unbroken circle, as shown in Fig. 1.

The only difficult moment is that in which the last piece is to be inserted in the circle. It is necessary to hold the row of dominoes by one hand at the end where we began, and to have carefully reserved a space for the last piece.

Suppose the problem is not to form a circle, but to arrange the dominoes in a straight line. This is no more difficult than the other. Having placed one of the pieces in an oblique position against the cover of the box, it is necessary to juxtapose all the other pieces with the same inclination against the edges of those that immediately precede. The placing of the twenty-eight pieces is extremely easy; the only critical moment is the one in which the initial point of support is removed, since our experiment admits of the aid of no foreign object. It is then necessary to employ both hands. The left gently pushes the row toward the right as if to straighten up the inclined dominoes, while the right feebly resists this impulse in order to prevent the row of pieces from standing erect upon their bases. After a few tentatives, the equilibrium becomes stable, the hands may be taken away, and the row will stand from one end to the other in the position shown in Fig. 2. —*La Nature.*

THE ACTION OF LIGHT ON WATER COLORS.*

DR. W. J. RUSSELL, F.R.S., and Captain Abney recently issued their first report dealing with the physical effects of light on water colors. Their investigations have been undertaken at the request of the Lords of the Committee of Council on Education, and the present Blue Book is the outcome of the first two years of their work. They have endeavored to determine the nature of the optical changes as well as the chemical changes which take place in the fading of colors, and have found out many of the causes which initiate and accelerate these changes. They have at present published the results of the experiments, dealing especially with the nature of the optical changes, and it is proposed to treat of the chemical changes which simultaneously occur, in a separate report.

In determining the true value of colored pigments, they have ascertained a quantitative measure of the light reflected from a painted surface, by projecting upon it the different colored rays of the spectrum, and then collecting the rays reflected from the surface. The recombined rays give a true measure of the color of the pigment, and its brightness is then measured in terms of the brightness of the same color reflected from white paper. The source of light employed was the electric arc light; but it is obvious that any other illuminating power could have been employed, as the relative intensities of the different colored rays would be the same whatever the source of light employed. The soluble coloring matters which are precipitated as lakes behave in the same way as the solid pigments, so that when white light falls on their surfaces it is partly transmitted and partly reflected, giving a colored reflected light. A certain amount of white light is, however, reflected as such, so that the color of a pigment always contains a certain percentage of white light together with the colored light. With soluble colors, the white light passes through the stain and loses certain portions of its original spectrum colors; it is then reflected from the white surface of the paper beneath, and reaches the eye as colored light. The light reflected by colors is often different from that transmitted by them. Carmine, for example, trans-

* From an abstract in *Industries.*

VASISTAS, WINNER OF THE GRAND PRIZE, PARIS.

mits less light than it reflects, while Prussian blue gives very nearly equal amounts of reflected and transmitted light.

In the report, especial importance is attached to the total amount of energy reflected from a colored surface. It is obvious that of the total energy falling on the surface only a portion is reflected, in the same way that, when considering only the visible rays, part only of the color is reflected. It is thought the ultra-red and ultra-violet rays which fall on a colored surface, when partly absorbed by the pigment, have an important influence upon the changes in color of the pigment. Although the energy existing in the ultra-violet rays is small in amount, yet it is present in them in a condition which may cause a destructive vibratory motion of the atoms of the molecules of the pigment on which the light falls. The total amounts of visible and invisible rays which are absorbed by the pigment are not lost, but are transformed in the molecules of the color into other forms of energy, which perform work of some kind in it.

This work may be a raising of the temperature of the body, a chemical decomposition of the molecules, or a rearrangement of its atoms. The raising of the temperature is shown by direct experiment to be very slight, and is insufficient to cause any appreciable change of color in the pigment. It is also obvious, from the smallest of the particles, they have a relatively large surface to their volume, and consequently when the temperature is raised by absorption of rays the radiation from the particles is very great, so that they rapidly cool to the surrounding temperature. When chemical decomposition is a result of the absorption of energy rays, then the relatively large areas of surface exposed tend to hasten the splitting up of the compounds, and explain the rapidity of the fading when due to this kind of action. Intensity of radiation and the time during which it acts are the two factors which have to be taken into account in estimating the chemical action effected.

The chemical decomposition appears to be due to well timed impulses which are directed at or on the atoms comprising the molecules of the pigment. The rays of light which are absorbed, if they act upon the molecules of the pigment for a sufficiently long time, will, by their regularity, in time increase the swing of the atoms composing the molecule to such an extent that they will swing off from the molecule and determine its decomposition. The liberated atom is then free to combine with the oxygen of the air present, with water, or to act in other ways.

It is pointed out in the report that this sort of action takes place on a photographic plate, even in the $\frac{1}{1000000}$ of a second, in sunlight, while chemical change takes place in the silver salts long before such change is visible to the eye. Experiments on the fading of colors which are now concluded were also undertaken to ascertain the part of the spectrum which was most active in producing the fading action. For this purpose, sunlight and colored glasses were employed, and they proved that if fading were possible, it took place to the maximum extent under blue glass, in a lesser degree under the green, and only rarely under the red glass. Since the fading was least under the red glass, the experiments show that the fading of the colors examined was not due to the dark rays; but that the blue, violet, and ultra-violet rays are those which are by far the most active in producing a change in the pigments which have been investigated. In order to ascertain whether the dark rays by heating the materials might not aid the rapidity of decomposition, comparative experiments were made in which one set of colors was exposed to light on a surface heated to 100° C. for the same time, and under otherwise similar conditions to another set, and it was found that with the majority of pigments the rate of change was sensibly the same. Damp is often a factor in the rapidity of fading, and heat, by lessening the amount of moisture present, may therefore probably retard the change of color.

From the fact that fading takes place with greatest rapidity under blue light, it follows that sunlight is safer than skylight when reduced to the same degree of intensity, since it contains a smaller proportion of blue rays. In their experiments Dr. Russell and Captain Abney have endeavored to ascertain from a consideration of the amount of sunlight and daylight, and the quality of the same, to which their specimens were exposed, the exact amount of illumination equal to that of an average blue sky which has brought about the fadings which they record. Their approximate estimation is that the pigments received a total illumination equivalent to 2,225 hours of average blue sky, and they further estimate that the pictures as hung in the galleries at South Kensington would not exhibit the same degree of fading under 100 years. With gas light or in the light from the electric glow lamps, at least 2,000 years of continuous illumination would be required to produce the same effect, and about 300 years if an arc electric light were the source of illumination. These estimates are based on the amount of time which passed from the beginning of the experiments to that when they were first examined, viz., from May, 1886, to the middle of August of the same year. The tubes were, however, kept exposed until March of last year, and using the same data, it will be seen that a total of 10,800 hours of average blue skylight is the complete amount of light which the pigments have received.

The colors experimented with were moist water colors, and they were tested singly and in mixtures of two or more colors. The paper used was Whatman's, and special experiments were undertaken to ascertain the amount of moisture which the various qualities absorbed in a given time. Strips of paper two inches wide and eight inches long, having eight tints of the same color upon them, were introduced into glass tubes, and hung on a wall facing the south, one-half of the color being protected from the light. In the first set of experiments, light, air, and moisture acted upon the colors of the thirty-nine single colors examined, twelve only were not acted upon at all by the light, and two others were only after long exposure to direct sunlight very slightly faded.

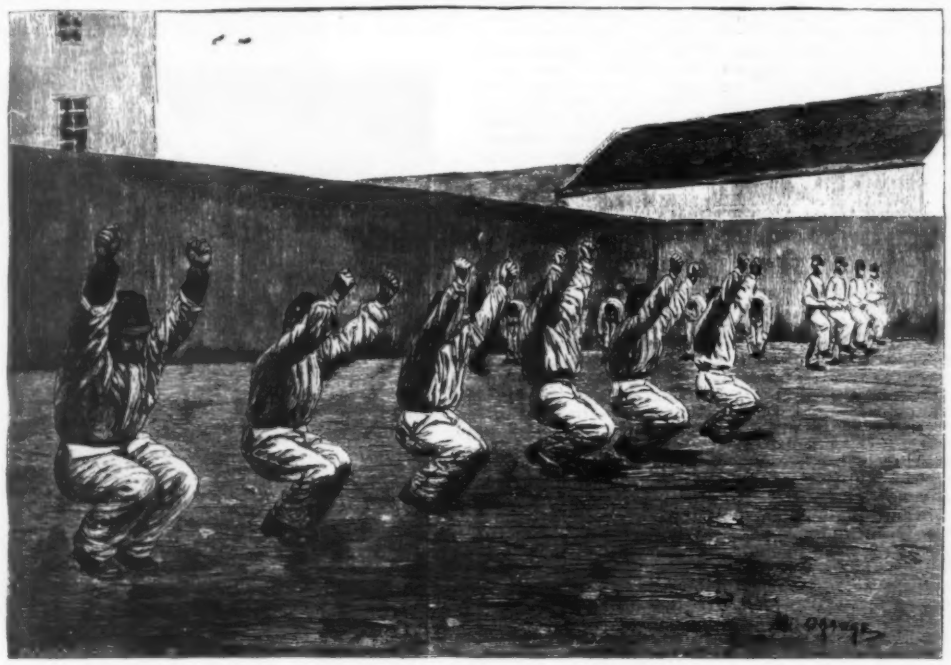
The twelve permanent pigments are: Yellow ocher, Indian red, Venetian red, burnt sienna, chrome yellow, lemon yellow, raw sienna, terra verte, chromium oxide, Prussian blue, cobalt, French blue, and ultramarine ash. All of these, except Prussian blue, are purely mineral colors. The following mixtures also underwent no change: Raw sienna and Venetian red, raw sienna and Antwerp blue, cobalt and Indian red. Carmine, crimson and scarlet lake, Payne's gray, and Naples yellow are the most fugitive of the colors examined. In another set of experiments with the same pigments moisture was excluded, when it was found that the number of permanent pigments was increased to twenty-two, the additions to the list being principally those which were only slightly faded in the first set of experiments. When the colors were exposed to air fully saturated with moisture, only ten colors withstood the action of the light.

The report also shows the influence of oxygen upon these changes, as, when the colors were exposed to light in tubes filled with moist hydrogen, 22 out of 36 remained permanent. When both air and moisture were carefully excluded, and the colored papers exposed in vacuous tubes to the light, still less change of color was observed, hardly any color fading even after long exposure. The addition of ox gall had no influence upon the results. With the electric light, the only single colors which underwent change were crimson lake and carmine.

Several other sets of experiments are detailed in the Blue Book. The report concludes with a summary and the more important inferences which the authors have drawn from their labors. Mineral colors are far more stable than vegetable colors, and every pigment is permanent when exposed to light in vacuo. Although by condemning the use of vegetable colors several popular pigments are excluded from use, there are a considerable variety of good mineral colors available. If vegetable colors must be used, efforts must be made for the exclusion of air and moisture as far as is practicable from the paintings. When mixtures are employed, it is important to recollect that if the two pigments have no chemical action on one another the unstable one may fade, and thus change the color of the combination. The blue and violet rays, which are the most active in causing fading to take place, are fortunately the rays which are in comparatively small proportion in the artificial lights usually employed in lighting picture galleries. The rate of fading as shown by these experiments is very slow in galleries lighted like those at South Kensington, and in rooms illuminated with gas light or electric glow lamps the rate is so slow as to be reckoned by thousands of years before the fading is marked. No definite experiments have as yet been published showing the deterioration due to the action of the products of combustion of coal gas; but so far as is known at present, this cause of fading is not one of great importance. The report concludes by the suggestion that skylights glazed with a glass of a slightly yellow tint, or blinds of a yellow color, might with advantage be used for retarding the action of light upon water colors, and they would, at the same time, when the illumination is from the blue sky, impart the tone of diffused sunlight to the picture.

EXERCISE WITHOUT APPARATUS—INSTRUCTION OF RECRUITS.

A FEW years ago, there was an individual in Paris who exhibited a dancing turkey. The poor animal was placed on a piece of hot sheet iron, and the pain from the burn forced it to lift its feet alternately. We thought of this a few days ago on seeing the young recruits engaged in the varied and apparently whimsical exercises that we ourselves have many a time gone through. Each of the motions reminded us of the sufferings endured by the greenhorn; the sort of intellectual stupefaction or rather torpor that succeeds those long days in which one is deafened by the oaths of the corporal—that terrible god whose gesture makes the future conquerors of the world tremble—those days in which one can no longer recognize his right from his left when the captain looks him through and through, and in which the vision of the guard room, which ever hovers over his head, leaves to the body broken up by these maneuvers but one desire—that of sleeping for a long time, of sleeping forever.



FLEXION OF THE LOWER EXTREMITIES AND VERTICAL MOTION OF THE ARMS WITHOUT FLEXION.

"Flexion of the lower limbs and vertical motion of the arms without flexion! Begin!" Behold all our clumsy fellows, looking awkward in their new duck suits, and as stiff as statues of the middle ages in the folds of their garments of stone, behold them sitting on their hams, the arms thrust forward, and rising slowly, all together, and then squatting again, and afterward performing this tiresome exercise twenty or thirty times over again, and having it seasoned with orders for those who fail to be convinced.

FLEXION OF THE THIGH AND LEG.

Now observe the turkey's dance, which is beginning again. . . . "Flexion of the leg and thigh! Begin!" The heaviest lose their balance, and the others, bracing up and opening their frightened eyes, clench their fists, dumfounded by the orders. Ah, ladies, you would laugh heartily should you at this moment perceive your brilliant dancers of yesterday, and we think you would have much trouble to recognize them! Is not that big bag of coarse duck that has just earned three days of yard sweeping for deficiency in the rotation of the arms—is not that Gontran de Z——, the model of Van Beers and your dancer of handsome shape? And, upon our word of honor, there is our friend ——, the fellow of philosophy, the delicate spiritualist, thoroughly confused and losing his dignity and scandalizing the adjutant. "He is a bachelor," yells the latter, "and he does not even know how to perform the flexion of the arm in double quick!"

"Ha-a-alt!" We laughed again on taking our departure, and yet no one knows better than we the utility of these odd gymnastics, which are so indispensable for polishing our blockhead peasants and for converting them into agile soldiers broken in to all the fatigues of the calling, and very necessary also for making those Norman troopers who are so active and alert and who are so cheered at Longchamps.—*L'Illustration.*

FLEXION OF THE BODY BACKWARD AND FORWARD AND VERTICAL MOTION OF THE ARMS WITHOUT FLEXION.

READING AS A MEANS OF TEACHING LANGUAGE TO THE DEAF.*

"I would have a deaf child read books in order to learn the language, instead of learning the language in order to read books."

IT delights me to observe in America a gradual change from the scholastic method of teaching language to that which has been so properly called by Mr. Scott Hutton the "natural method." But there is one point in the natural method to which I would direct your attention.

When we study the methods by which languages are naturally acquired by hearing children, we observe that comprehension of the language always precedes a child's attempt to express ideas in that language—he understands the language before he uses it; whereas, in our attempts to apply the natural method to the deaf, we try to make the child use the language before he understands it.

I was very much struck by the remark of Mr. Job Williams, that it is practice, practice, practice, that gives a perfect command of language; that *it is the frequency of repetition of words that impresses them upon the memory.* Now, what sort of repetition do we give to the hearing child? Will any member of this conference make the experiment? It is an interesting one. Take a book intended for children's use, and read it aloud. Test the speed of your reading, and you will find that two hundred words a minute is not a rapid rate.

A stenographer would say that one hundred and fifty words a minute is above the average rate of public speaking; but this is for language in which long words are of frequent occurrence, and where a deliberateness of utterance is employed that is uncommon in talking to children. Not only do short words predominate in our conversation with children, but mothers and nurses gabble at such express speed that a stenographer would probably give up in despair the attempt to transcribe the conversation. I am convinced from experiment that the average rate of nursery gossip exceeds two hundred words a minute. However, to be well within the mark, let us assume one hundred and fifty words as the average rate, and calculate upon this supposition the number of words presented to the ears of a hearing child in the course of a day. Let us suppose that if these words were concentrated into one continuous talk, without any pause, it would amount to a speech of four hours in length, and surely this is not an excessive assumption. One hundred and fifty words a minute amounts to nine thousand words an hour, or thirty-six thousand words in four hours. This means that we shower at the ears of the hearing child no less than thirty-six thousand words a day; and as the whole vocabulary we use in talking to children hardly exceeds three hundred words, this means a very great daily repetition.

We not only talk to a child at the rate of thirty-six thousand words a day, but we do this for three hundred and sixty-five days in the year (we do not stop on Sundays); and we do this for two years at least before we expect the child to turn round and talk to us. If then we attempt to apply to the deaf the natural method of learning language, what sort of repetition of words to the eye should we give the deaf child before we exact from him any great efforts at English composition? In the natural method of learning language, *comprehension always precedes expression.*

But in our schools for the deaf this process is generally reversed. For example: In our sign institutions a story is told in signs, and pupils who know little or nothing of the English language are required to go through the drudgery of writing out the story in words. Would not the converse process be more natural and profitable? Even in schools where the sign language is not employed, action writing is largely resorted to. For example: A teacher will take a book from a pupil, open it, pretend to read it, then close it and lay it upon the table. She then asks her class to express in English words what she has done.

While this plan furnishes an admirable exercise in composition for older pupils, it is surely out of place with pupils who cannot understandingly read an ordinary book. It reverses the process of nature, which demands that comprehension shall precede expression; that *a child must understand a language before he uses it.*

Now, we know perfectly well that if we can repeat words to the eyes of deaf children with anything like the frequency and clearness with which we present them to the ears of the hearing, the deaf will come to master the language by the same natural process that produces comprehension in the hearing child. The great difficulty is how to do this. The speed of writing, even at a scribble, hardly exceeds thirty words a minute. The speed of the manual alphabet can be made to approximate one hundred words a minute, but very few teachers exceed an average speed of eighty words per minute. It is obvious, then, that the teacher cannot, by his own exertions, even approximate to the speed of speech.

Is there no hope, then, for the deaf child? Must the acquisition of English always be to him a long and laborious task? Must he acquire imperfectly, after years of labor, a language which is mastered by the hearing infant before he is four years of age, and which foreigners, commencing at the age when the deaf child enters school, acquire in a few months? I do not think so. I think that there is hope for the deaf child by the adoption of a plan that can be ingrafted on any system of instruction.

Though the speed at which we write is limited to about thirty words a minute, the speed at which we read is very different, especially when the words are presented in print so that the letters are clear and unambiguous. I gave an interesting novel the other day to a friend, and noted the time when the reading began, and also the time when the book was closed. I then made a calculation of the number of words read, and I found that *more words had been read in an hour and a half than a hearing child hears in the course of a day.*

Other experiments have convinced me that the speed of silent reading, at least for those who know the language, averages from three hundred to even four hundred words a minute. I say, then, there is hope for the deaf, by putting books before them and accustoming them to form the habit of reading.

I would urge upon all superintendents and principals of schools for the deaf the importance of introducing reading as a regular school exercise, for the purpose of teaching language. I would introduce into the very youngest classes the practice of reading, *regardless of the fact that the children may not understand the meaning of the words on the printed page before them.* By this practice a repetition of words to the eye would be secured, which could not probably be obtained in any other way, and reading would co-operate with the regular instruction of the schoolroom to bring about a gradual comprehension of language.

I would place in the hands of the youngest pupils, in printed form, the stories that hearing children love to hear, and require them to read those stories, whether they understand them or not, without giving them any explanation of the meaning. Then, after their allotted task is completed, I would give them a reward.

I would show them a picture, or act the story out in a natural pantomime. I do not hold, with many of my friends, that signs have not their use. I believe that signs, like pictures, are capable of being used so as actually to facilitate the acquisition of our language by the deaf. *The proper use of signs is to illustrate language, not to take its place.*

I do not know, however, if you will applaud me when I say that I do not here allude to the sign language. There is the same distinction between pantomime and the sign language that there is between pictures and the Egyptian hieroglyphics. Egyptian hieroglyphics consist of abbreviated conventionalized pictures, just as the sign language consists of abbreviated conventionalized pantomime. No one will deny that the exhibition of a picture may add interest to the story that we tell a child. It illustrates the language, and it may be of invaluable assistance to him in realizing our meaning; but is that any reason why we should teach him English through Egyptian hieroglyphics?

The moment you teach one language through another, the pupil thinks in the language of communication, and acquires the other as a foreign tongue, just as the hearing children in our public schools continue to think exclusively in English, however many languages may be included in their curriculum of studies. The natural method demands that you shall teach a language *by using it for the communication of thought without translation into any other tongue.* If you want your child to learn German or French, the English language is an obstacle in the way, and retards his mastery of the foreign tongue, just as the use of the sign language in our institutions retards the acquisition of English. If you send your child to Germany or France, or so surround him with German or French speaking people that communication is carried on exclusively in one or the other of these languages, he acquires the French or German as a native tongue.

* An address delivered before the sixth national conference of superintendents and principals of institutions for the deaf (Gallaudet meeting), held at the Mississippi Institution, Jackson, Miss., April 14-17, 1888, by Alexander Graham Bell.—*Science.*

FLEXION OF THE BODY FORWARD.

I have no doubt that all things have a use, and even the sign language may have a use in missionary work among the adult deaf; but I do not think it should have a place in the school, or be used in the instruction of the young, for it comes between the deaf child's mind and the English language he is striving to master.

If words are impressed on the memory by frequency of repetition, then *the duller a pupil is the more necessary is that repetition*, and the more harmful the sign language.

But I am wandering from the subject. If we make a deaf child, perforce, as a regular school exercise, read, not a few paragraphs, but pages upon pages of a book, he will obtain that repetition to the eye which the teacher cannot give him by writing or by the manual alphabet. Let the pupil spend half an hour or an hour a day in reading (or spelling upon his fingers) the language that describes a fascinating tale. Do not show him a picture, do not make him a sign, do not give him any explanation of the meaning until he has finished his allotted task. Then let the story be acted out, and let pictures be freely used, till he gets the meaning, not necessarily of the individual words and phrases, but of the story as a whole. He learns thus that the printed language in the book expresses a pantomime, or a series of pictures; that it represents, indeed, a narrative that absorbs and fascinates him.

Now, when he is called upon to go through his next daily task, he knows that the language expresses a story of some kind that will interest him, and all the time he is reading or spelling, his mind is being exercised. Curiosity compels him to speculate, and he wonders what sort of a pantomime will be acted out, what sort of pictures will be shown him. *He frames in his mind a hypothetical story*, which may or may not be right, but the pantomime or pictures will ultimately correct it. *He is deriving ideas of some sort directly from the printed words.* This is the sort of exercise that the child needs. This is the kind of mental operation that goes on in the mind of the hearing child when he sits on his father's knee, and listens to the story of adventure or to the fairy tale. In both cases the comprehension of the language is imperfect; in both cases errors are corrected and interest aroused by the exhibition of pictures or by the use of dramatic gestures and natural pantomime.

I therefore strongly recommend the introduction of reading as a school exercise—the introduction of interesting stories expressed in ordinary language, idiomatic phrases and all, not language stilted in expression, containing sentences exclusively arranged upon simple grammatical models. If the pupil is to make progress in his knowledge of ordinary language, the language must be above him, and not degraded to an unnatural level. Teachers may say, "Why use idiomatic phrases that cannot possibly be explained to the deaf child?" But he never can come to understand them until he has seen them, any more than the hearing child can understand them until he has heard them. The hearing child learns to understand by hearing, and the deaf child will come to know by seeing. Frequency of repetition will impress the idiomatic phrases on his mind, and much reading will bring about this frequent repetition in ever-varying contexts.

I may allude here to an experiment that I made upon myself, which has an important bearing on this whole subject. I obtained a work upon the education of the deaf, written in the Spanish language (of which language I knew nothing). I determined to ascertain how far I would come to understand the language by forcing myself to read the book. I read very carefully thirty or forty pages, and could make but little of it. The Latin roots helped a little, and I understood a few technical words here and there, but that was all. I refused at first the aid of a dictionary, for a dictionary stops the current of thought. I read thirty or forty pages, and then paused.

Now, a number of words had occurred so frequently that I remembered them, though I knew not their meaning. These words I sought in the dictionary, and then I resumed my reading. I found that these words formed the key to the next thirty or forty pages, and that the meaning of many expressions that would otherwise have been obscure became manifest. New words also explained themselves by the context.

Every now and then, after reading a few pages, I resorted to the dictionary, and sought the meaning of those unknown words that I could remember without looking at the book. I then turned back to the beginning and read the whole a second time, and I was delighted to find that a very great portion of the meaning of that book revealed itself to me. Indeed, I felt convinced that, if I wanted to comprehend the Spanish language, all I had to do was to read, and read, and read, and I should come to understand it.

The application to the deaf is obvious. The methodical instruction in the schoolroom, and the efforts of the teacher, take the place of the dictionary to the deaf child, and reading, reading, reading, with a desire to understand, will give that frequency of repetition to the eye that is essential to the mastery of language. To express the theory in a single sentence, *I would have a deaf child read books in order to learn the language, instead of learning the language in order to read books.*

Now, the books that are best fitted for this end are not those which are most commonly found in school libraries intended for the use of deaf children. We may be guided in our choice by the age of the child. We should place in the hands of the child such books as are of absorbing interest to hearing children of his age. If we wish the child to learn language, quantity of reading is more important than quality. For little children, such stories as "Jack the Giant Killer," "The Three Bears," "Cinderella," and all the host of fairy stories that so fascinated us when we were children, will be the best. For boys of twelve and thirteen I am afraid that the so-called "blood and thunder" novels would teach more language than "Stanley's Travels in Central Africa," or the best text books of history. It is not necessary, however, to place in the hands of deaf children books of doubtful character, in order to give them reading of absorbing interest, while the press of this country continues to furnish such fascinating, entertaining, and at the same time elevating and improving literature for the young as has been prepared for them by such writers as Louisa Alcott, Elijah Kellogg, Margaret Sangster, and the scores of other authors of juvenile books of our time. A plentiful supply of interesting tales should be provided, sufficiently short to be read through at a single sitting, and of a character that could be illustrated by pictures and natural pantomime. Of course, suitable selection must be made of subjects; but I cannot too strongly impress upon you my conviction that, *for language teaching, mere quantity of reading is more important than quality.* For advanced pupils, the society novels and plays that are usually banished from the libraries of our institutions are what are wanted, especially those society novels that are written in conversational style and abound in questions and answers. Ordinary books of history and travel are too often written in what may be called "book language," and not in the language of the people. But in novels and plays will be found the language of conversation, and these also are the books that will stimulate the pupil to read.

As your pupils become familiar with the printed page, they will take in words by the eye with greater and greater rapidity, until ultimately a speed of reading will be obtained of from three hundred to four hundred words a minute. Think what this means if the child reads for only an hour a day during the whole period of his school course! Think, too, of what value the habit of persistent reading will be to your pupils in adult life!

I believe that, in the acquisition of language by the deaf, reading will perform the function that hearing does for the ordinary child. I do not think that any more important habit can be formed by the pupil than the habit of reading; for after all, the utmost that you can do for his education in his school life is to introduce him to the wider literature of the world.

THE COLLECTION AND PRESERVATION OF PLANTS.*

Preservation of Dried Plants.—Dried plants are apt to be destroyed by insects, and large collections would soon become the prey of the larvæ of *Anobium*, *Ptinus*, etc., were not the precaution taken to protect them against the attacks of these pests.

Certain persons are content to keep their plants in tightly closed cases in which they place phenic acid, camphor, or oil of thyme. Others, once or twice a year, place their packages of plants in a box especially constructed for the purpose, and therein impregnate them with the vapor of sulphide of carbon. How dangerous it is to handle this substance is well known, and it should be used with great caution. The sulphide box should be lined with zinc, and should be closed hermetically by a well-adjusted cover, whose prominent flange enters a gutter, which may be filled with water, and which is affixed to the upper part of the box. After placing a vessel containing a certain quantity of sulphide of carbon at the bottom of the box, the packages are put in place, each being partially opened, so that the vapor disengaged may penetrate everywhere. After the box is closed it should remain so for several days, after which the cover is removed and the packages are exposed to the air until the odor of the sulphide has entirely disappeared. There is a process of preservation which is more generally employed, and which consists in immersing the specimens in the following solution:

75 per cent. alcohol	1 quart.
Bichloride of mercury	1¼ oz.

This liquid is a very violent poison, so the use of it requires great precautions. The following formula is sometimes preferred, because the sublimate preserves its properties more intact:

90 per cent. alcohol	1 quart.
Water	2¼ oz.
Bichloride of mercury	1¼ oz.
Muriate of ammonia	¾ oz.

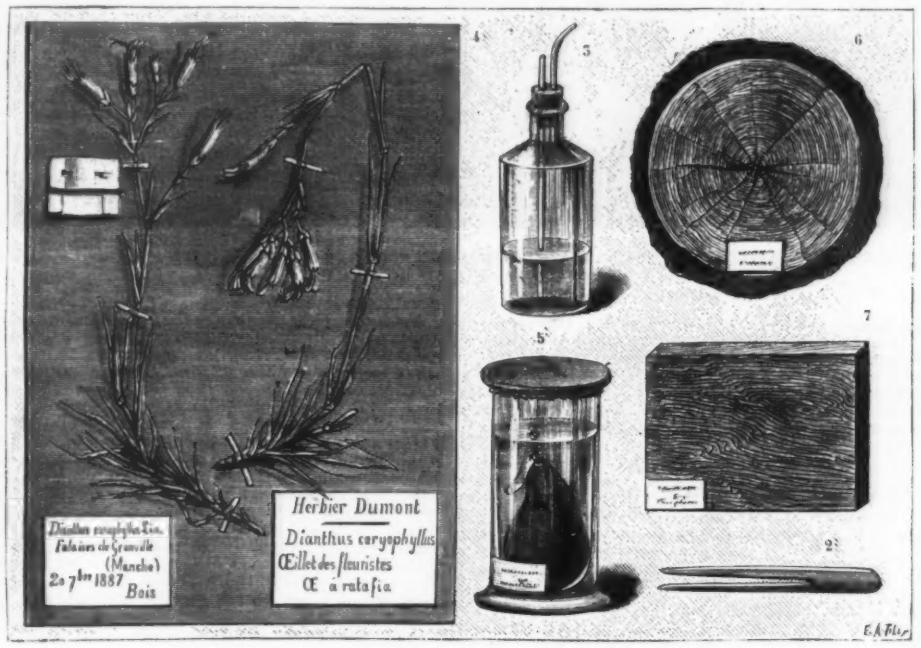
The bichloride is dissolved in the alcohol, the muriate in the water, and the two solutions are mixed.

The plants are immersed in the liquid as follows: A deep porcelain plate of rectangular form, and a little larger and wider than the herbarium paper, is filled with the solution and placed upon a table between a package of plants to be poisoned and a package of driers. Then the tickets are detached from the first specimen, so that they may not be ruined by a stay in the alcohol, and, as a greater precaution, in order to prevent any soiling contact, they are fixed with pins so that they project externally upon a wrapper. (A good supply of wrappers should be within reach.) This wrapper thus prepared is placed upon a drier, and then, with wooden or whalebone nippers (Fig. 2), the specimens are seized and immersed in the liquid. Nippers made of metal should never be used for this purpose. The form that we figure is the one adopted at the Museum of Natural History, and can be easily made by any one for himself.

After the specimens have remained in the liquid for a short time, they are taken out with the nippers and allowed to drain; then they are placed in the cover, which is closed and covered with a drier. The same operation is performed on the rest of the specimens. As soon as a large enough package has been formed it is put in a well-aired place, so as to permit of the evaporation of the alcohol. At the end of twenty-four hours it is necessary to replace the damp driers by dry ones. A longer stay in them would blacken the specimens.

It must not be thought that the specimens thus prepared are forever proof against the attack of insects. The herbarium should be often inspected, and a few drops of preservative liquid be thrown upon such specimens as are beginning to be attacked. This operation may be very easily performed with the bottle represented in Fig. 3. This is closed with a rubber stopper through which pass two glass tubes, one for the passage of the liquid and the other for the entrance of air.

Certain families of plants are much more sought after than others by insects. As a general thing fleshy plants and those that contain starch are the first ones eaten; the grasses, ferns, and mosses, on the contrary, are very rarely attacked. After the plants have been poisoned, it only remains to arrange them in the herbarium. To this effect, they are fixed upon simple sheets of strong, sized paper, in such a way that they will hold well. Thus prepared, they are put in wrappers. The mean dimensions of the mounting paper are 12×18 inches.



THE COLLECTION AND PRESERVATION OF PLANTS.

For fixing the specimens, use is made of small straps of gummed paper arranged here and there in such a way as to hold all the parts without, however, concealing them (Fig. 4). Instead of straps, some persons use pins, but the use of these is more difficult, and they have the drawback of breaking the delicate parts of plants by their contact. The specimens must not be glued to the paper, but should be detachable at will, so that they can be thoroughly examined when necessary. Several species should never be fixed upon the same sheet.

Large specimens, the lichens, with their support, and certain fungi can be fixed only upon very strong paper or even upon cardboard, and it is sometimes indispensable to sew them on with cord. In order to prevent them from injuring the neighboring plants in the package, good cushions of soft paper should be interposed. In all cases, sufficient space should be reserved at the bottom of the sheet for the reception of the labels. To the left is placed that of the collector or of the person from whom the specimen was received. This label should always be carefully preserved, for it is the one that must give authority in the case of doubt. It should bear the number and the notes taken in the memorandum book. When it is a question of *exsiccati*, that is to say, of collections of which several examples exist, the numbers permit of easily finding the names of the plants when the latter are described and published. To the right is placed a label by itself sufficiently large to allow bibliographic data and observations to be added to the name. The flowers and fragments that become detached during the preparation of the specimens must not be registered, but should be preserved in small envelopes, and whenever it is desired to make an analysis, it is better to use them than to injure one's collection. The sheets filled with specimens are placed in wrappers, and it only remains to classify them by families and put them in packages, which should be arranged in tight cases in a dry place, and where the temperature is as equable as possible. Care should be taken to allow nothing to enter the room devoted to the collection that could attract insects, and never to allow plants to enter it that have not first been poisoned. Several sheets on which are mounted species

* Continued from SUPPLEMENT, No. 706, page 11288.

belonging to the same genus may be inclosed in the same wrapper. To the upper right hand corner of the wrapper should be glued a small, conspicuous ticket bearing the name of the species. This renders researches much easier.

Conspicuous tickets are also used for the genera, but these are fixed upon simple sheets, so that they can be easily shifted. They must be very distinct from the preceding. They may, for example, be made longer and of a different color. They are usually affixed to the middle of the sheet. The family ticket should be larger still, and also of another color. It is fixed to the left of a simple sheet.

The herbarium packages should not be too bulky. They are kept between cardboards fastened together with straps.

An excellent measure taken at the herbarium of the Paris Museum consists in placing the species, according to their country, in wrappers bearing labels of various colors corresponding to the five parts of the world. White indicates European species, yellow represents those of Asiatic origin, blue is for Africa, green for America, and red for Oceanica. This arrangement permits of easily finding the species in which one is interested when he is making researches upon the flora of a region. Besides, it shows at a glance the geographical distribution of each species, genus, and family.

Collection of Fruits.—A collection of fruits is the indispensable complement of the herbarium. To render work easier, it is well to place it as near the latter as possible.

After well washing the freshly gathered fruits in order to free them from foreign matter (care being taken during the operation not to rub them in such a way as to deprive them of certain important characters, such as color, villosity, etc.), they are put into jars containing alcohol and water. These fruits should carry a securely fastened parchment label, on which is written the number of the memorandum book. The lead pencil has the advantage over ink that the writing does not become effaced in alcohol; yet, for greater safety, it is preferable to form the numbers with a punch. A series of figures does not cost very dear, by reason of the security offered by the tickets that it permits of making.

If a person is traveling and wishes to ship the fruits, he will merely have to close the jars tightly with good corks covered with a thick layer of bottle wax. Sealing wax dissolves in alcohol, and it is therefore very important to have corks that adjust themselves perfectly to the vessel if one wishes that the corking be not defective. The jars should be carefully packed to prevent breakage. They should be accompanied with a catalogue bearing notes from the memorandum book opposite the numbers.

When it is desired to arrange the fruits, it is often necessary to change the alcohol, which, in certain cases, rapidly darkens. The liquid should be changed several times, until it remains of sufficient limpidity.

A large number of systems have been devised for closing the jars. A cork stopper, when of good quality, has the advantage of being easy to insert and extract, and that is to be taken into consideration if it is necessary to examine the specimens often. At the museum we use jars with a lip (Fig. 5), which are covered with glass disks held by glazier's putty. After the latter is dry, a piece of bladder is glued to the disk and its edges are tied around the neck with a string. Finally, the whole is covered with thin tin foil. There is nothing further to do but to put a label on the jar bearing the name of the fruit, its origin, and the name of the collector. As the same number is carried by the specimen in the herbarium and the jar containing the fruit, it permits of easily bringing together these parts when it is desired to study them.

Dry fruits are simply put into glazed boxes or into bags or jars.

The classification of the collection of fruits should be done in the same order as that of the herbarium.

Collection of Wood.—Specimens of woods should be kept in a separate room from that of the herbarium. They usually contain numerous insects' eggs, and, from time to time, they should be put into the sulphide of carbon box. They should, as far as possible, be of uniform dimensions, and, in order that the structure of the wood may be well seen, the same species should be represented by a longitudinal and transverse section (Figs. 6 and 7). Specimens of wood should be labeled and classified with the same care and in the same order as the other collections.

Classification of Collections.—It is indispensable to classify collections and to catalogue them, so that the objects that they contain may be easily found and one may know what he owns. The catalogue should be numbered and the numbers be placed upon the tickets of the genera and species to which they correspond. This considerably facilitates researches. In order to avoid beginning a new numbering every time that additions are made, it is necessary to take works for one's guide that, as far as possible, contain the total number of genera or species of the region that one has taken as a limit.

Were it desired to collect the phanerogams of all parts of the globe, we might take Durand's Index Generum Phanerogamorum (which is, in a measure, the index of a work whose authority is recognized by all botanists) or Bentham & Hooker's Genera Plantarum. The genera are numbered therein and arranged systematically and alphabetically, thus permitting of quickly finding the place that they occupy in the vegetable kingdom.—*D. Bois, in La Nature.*

THE ELMORE COPPER PROCESS.

WE print below, from the *Electrician*, an abstract of a report upon some tests of the Elmore process which were recently carried out at the works of one of the largest copper manufacturers in France, under the superintendence of Mr. Stepney Rawson. The report itself, which we have had an opportunity of examining, is a very voluminous document, and bears evident traces of the care and skill which were expended to obtain accurate results. The summary, for which we are indebted to Messrs. Woodhouse and Rawson, is as follows:

It is well known that the process consists of depositing copper upon a rotating mandrel, from a sulphate of copper solution, but the valuable portion of the invention consists in the mechanical working of the surface of the metal from one end of the mandrel to the other by means of an agate burnisher under a few pounds pressure. By these simple means a remarkable change takes place in the constitution of the metal, which is found to possess extraordinary strength, coupled with a remarkable malleability, as may be seen from the results of the tests given below. The instruments used for arriving at the constants were a Charpentier ammeter and a Siemens potential galvanometer reading 0·01 volt per degree. The dynamo was a one horse power Gramme machine.

Work was carried on continuously for ten days with the exception of a short stoppage caused by an accident to the dynamo. The tubes are separated from the iron mandrels by pressure applied to the copper while the mandrel is being rotated in a lathe. The expansion of the copper is sufficient to enable the tube to slide off easily; but in regular work the method of expanding the copper by superheated steam will be employed, as it is simpler and cheaper. The mean current used was 56·7 amperes, giving a current density of rather more than 15 amperes per square inch of cathode surface. This very high current density is no doubt possible on account of the use of the burnisher, and is more than twice the maximum found advisable in ordinary copper refining without the burnisher.

The difference of potential across each tank was taken separately, the average being 0·9 volt per tank. In connection with this point it may be remarked that the E.M.F. does not reach its normal point until after about 36 hours; at the commencement it is about 5 per cent. higher. Connection is made with the rotating mandrel by means of a brush pressing on its surface. Notwithstanding this the steadiness of the voltmeter was practically complete, and, in fact, there appears to be an electrolytic action constantly going on between the brush and the surface of the mandrel, which tends to keep the contact remarkably perfect. The electrical horse power absorbed in the tanks and connections amounted to 0·28 horse power, and the total copper deposited amounted to about 104 lb.

A careful calculation, deduced from the known value of the mean current, showed a close agreement between the theoretical and the actual quantity of copper deposited. The thickness of copper deposited was 0·14 in., which is at the rate of very nearly ⅛ of an inch per week.

Exhaustive tests were made upon portions of the tubes after their removal from the baths. The metal had a breaking strain of 32·3 and 32·7 tons per square inch, with an elongation of 7·5 and 10 per cent. on 8 inches of length in the longitudinal and transverse directions respectively. In connection with the question of elongation, it should be remarked that in the ordinary practice the ductility of a metal is gauged by its elongation in the test machine.

With the burnished copper the ductility is very high indeed, while its elongation is relatively very small, a fact which shows that we are dealing with a new variety of the metal. This point was fully demonstrated by Mr. W. Parker, of Lloyd's, in a paper read before the Society of Arts, wherein he states that the ductility of burnished copper with a 13 per cent. elongation is greater than that of ordinary copper with an elongation more than three times as large.

The fracture of one piece in the testing machine was arrested the moment before it was completed, in order to display the extraordinary symmetry of the deposit; the metal begins to flow exactly at the center, and shows almost precisely equal percentages of elongation on either side of that line. The annealed test pieces, which, from the appearance of the metal, led to the conclusion that it had been overheated, gave a breaking strain of 15·4 and 14·8 tons, with an elongation of 23 and 31 per cent. on 8 inches.

It is well known that wire is made by this process by taking a deposited tube and shearing off a continuous square strip, beginning at one end and continuing until the whole of the tube has been cut into one continuous length of copper strip. This does away with the numerous processes of remelting, casting, and sawing up, by which all high conductivity wire is made.

Portions of the tube were drawn down from a thickness of 3·4 millimeters to 1 millimeter through 14 hard holes without annealing, instead of having to be annealed every few holes. A test of this wire gave a breaking strain of 35 tons per square inch. Another sample of the same diameter was annealed and then drawn through 13 hard holes to a diameter of 0·98 millimeter, giving a breaking strain of 32·4 tons per square inch. A portion of this wire annealed and drawn through 7 holes to a diameter of 0·53 millimeter, and then annealed again, gave a breaking strain of 20·4 tons per square inch, with an elongation of 35 per cent. on 4 inches of length. Another portion of the tube was annealed and rolled cold from 3·5 millimeter to 1 millimeter thickness, and gave when finished 26 tons per square inch breaking strain.

In both the wire drawing and the rolling the metal showed very exceptional qualities as regards ductility, and the above figures are sufficient evidence of its extraordinary strength. In addition to this, however, some interesting experiments were made of its behavior under the hammer. At first the opinion of the workman employed to make these tests was that nothing could be done with the metal on account of its hardness. In spite of this he was, however, perfectly successful in hammering a broad flange 2½ inches in width, on the edge of which he hammered out a tongue 0·012 inch, or less than $\frac{1}{75}$ of the ordinary thickness of the tube, without the slightest sign of a crack in the metal.

The extraordinary quality of the metal was plainly observable by the way in which the workman showed his hesitation in going any farther with the test, and his final opinion openly expressed was that it was impossible to break it under the hammer.

Several other exceptional tests were made, all of which were successfully withstood. It is impossible to give any exact idea of the value of these tests to those unacquainted with the nature of copper working, but it may be remarked that the single fact of the possibility of hammering a flange in the tube of this metal without once annealing places it in an entirely different category to any other class of tubes in which the annealing necessary to enable the tube to be worked robs the metal of a large percentage of its strength, whereas the burnished metal remains unimpaired at the very point where strength is principally required.

In one respect the copper showed a very remarkable difference from the ordinary metal. There is a growing tendency among engineers to regard the elastic limit of the metal as the real test of its commercial value in the matter of withstanding strains. In this respect the burnished metal shows a very high result, the ratio of elastic limit to breaking strain being as high as 61 per cent., and an English test on a similar tube gave a figure as high as 82 per cent. There are many indications that the limit of the reduction of horse power necessary for producing a given weight of copper has not yet been reached, but an inspection of the above figures will show what a small amount of motive power is required to produce a ton of copper in the form of finished tubes. The tests were carried out in the works of one of the largest copper producers in the world, and therefore ample opportunities occurred for comparing the new type of metal with the ordinary type, and it was plain that in every respect the superiority of the new was fully recognized by men thoroughly capable of judging.

DARWIN VERSUS LAMARCK.*

AFTER a brief sketch of the life of Lamarck (1744-1829), his theory was stated in his own words as follows:

"(1) In every animal which has not arrived at maturity, the increased and continued employment of any organ strengthens that organ gradually, develops it, enlarges it, and gives it a power proportional to the duration of its employment; on the other hand, the continued disuse of any organ gradually weakens it, deteriorates it, progressively diminishes its faculties, and finally causes it to disappear.

"(2) Every feature which, under natural conditions, individuals have gained or lost by the action of circumstances to which their race has been for some time exposed—as, for instance the results of excessive use or disuse of an organ—is preserved in reproduction and transmitted to the offspring, provided that the acquired changes were present in both parents."

The small changes thus produced and transmitted from generation to generation are increased in successive generations by the action of the same causes which originated them, and thus in long periods of time the form and structure of the descendants of an ancestral organism may be completely changed as compared with the form and structure of the ancestor.

Given sufficient time, these small changes can have produced man and the higher animals from simple primitive protoplasmic animalcules.

Prof. Lankester then pointed out the truth of the first law of Lamarck, but mentioned the preliminary objections to Lamarck's theory, which had prevented its acceptance by the naturalists of the first half of this century. He then briefly epitomized Darwin's theory as follows:

(1) All plants and animals produce offspring which resemble their parents on the whole (heredity); these offspring, however, exhibit also new and individual features differing from those of their parents (congenital variations).

(2) In nature there is a severe struggle for existence. Only one pair out of the many thousands often produced by a pair of plants or animals survive to maturity, and in their turn produce offspring.

(3) The survivors are those whose congenital variations have enabled them to gain advantage over their fellows.

(4) The surviving forms *may* be almost exactly like their parents, but often a departure from the parental form must be an advantage, however small. Such departure, or variation, when INBORN or CONGENITAL, not only enables its possessor to survive and produce offspring, but is handed on by heredity to that offspring.

(5) A successful congenital variation is intensified in the new generation bred from parents in both of which it had congenitally appeared.

(6) By this process of natural selection of advantageous congenital variations, operating in countless millions of successive generations, the transformation of simple into more elaborate forms of life has been effected.

The real difference between Lamarck's and Darwin's theories was then explained. Congenital variation is an admitted and demonstrable fact; transmission of congenital variations is also an admitted and demonstrable fact. Change of structure acquired during life—as stated by Lamarck—is also a fact, though very limited. But the transmission of these latter changes to offspring is NOT PROVED EXPERIMENTALLY; all experiment tends to prove that they cannot be transmitted. Semper's book on this subject was cited as a failure in the attempt to prove such transmission.

The causes of congenital variations were next discussed, and the "stirring up" of the germ plasma by the process of fertilization was pointed to as the chief.

Very minute congenital variations can be useful, and, therefore, selected; but congenital variations are not necessarily minute.

The subject of correlated variations was next mentioned, and their great importance pointed out. A mechanical model was used to explain this matter; it represented an antelope in which when the neck is made to elongate the legs simultaneously lengthen, while the horns disappear and the tail shortens.

The lecturer then gave examples of the successful explanation of cases by Darwinism where Lamarckism fails. Mimicry and protective coloring, adaptation of flowers to insect visitors, instincts of neuter insects, and Lamarck's chosen case, the giraffe, were among these.

It was then pointed out that breeders have never produced new varieties by transmission of acquired characters (Lamarckian), but always by transmission of congenital characters (Darwinian).

While all this tends to the complete rejection of Lamarck's theory, it is true that Darwin himself admitted Lamarckism as an explanation of some rudimentary organs (disuse) and of some instincts (transmission of acquired habit).

On the other hand, neo-Darwinians reject Lamarckism altogether, because 1, the fundamental fact of trans-

* Abstract of a lecture delivered at the London Institution, Finsbury Circus, on February 14, 1889, by Prof. Ray Lankester, LL.D., F.R.S.—*Nature.*

mission of a change of structure or habit acquired during the life of an individual by the action of external agencies is not only not proved, but is contrary to experience; 2, such transmission is highly improbable in view of the structure and origin of the reproductive germs; 3, even if admitted as possible, Lamarckism is not needed in order to explain the facts of the structure and habits of existing plants and animals, in addition to Darwinism.

Pure Darwinism is sufficient.

Finally, the lecturer dealt with some cases advanced by Lamarckians as favorable to their views, and gave their Darwinian explanation.

Among these were rudimentary organs, where the fully developed organ would not be injurious, *e. g.*, the intrinsic muscles of the human ear. These were explained by panmixia and parsimony of growth.

Blind animals in caves and in the deep sea, *e. g.*, blind cray fish, Thaumastocheles, and blind fishes, were shown to be best explained by the natural selection of congential blindness. Among a whole brood of animals swept by a flood into a cavern, or by a current into deep water, those with perfect eyes would escape by following the light, while those with congenitally defective eyes would remain and reproduce their defect in their offspring, and in each succeeding generation the same process of natural selection would be continued.

Wingless insects and birds were similarly explained.

Instincts, *e. g.*, "shamming dead," nest building, choice of food, were briefly considered, and shown to be explicable by Darwinism, and not by Lamarckism.

In fact, it was declared that, in proportion as our knowledge of any class of such facts is extensive and thorough, the Darwinian explanation is found to be correct and the Lamarckian inadequate and inapplicable.

A consideration of the mental evolution of man according to neo-Darwinism was promised as the subject of a future lecture. It was briefly stated that the results of education and circumstances, good or bad, cannot be transmitted, while hereditary qualities, good or bad, cannot be eliminated, except by selection in breeding.

The transmission of acquired experience does not take place by heredity, but (among civilized societies) by the agency of tradition and books.

In civilized societies the injurious effects of unlimited neglect of selective breeding is largely neutralized by panmixia, giving an average race, neither wholly good nor wholly bad.

METALLIC MANGANESE.*

By CHAS. BULLOCK.

THE properties of manganese, like those of iron, appear to differ according to the method used in the reduction of the metal. When obtained from the oxide by heating with carbon, most authorities agree in the statement that the metal oxidizes so readily in the air that it can be preserved only under "rock oil," or in well sealed vessels. In water it is said to "oxidize rapidly, with evolution of hydrogen, and crumbles into a dark gray powder."

Cast manganese containing eight per cent. of iron is said to be unalterable in the air.

In the year 1869, some manganese prepared after the process of Brunner (the reduction of the chloride mixed with fluorspar, by means of sodium) was found to have as little tendency to oxidation as iron.

Repeating recently this process, pure chloride of manganese was fused in a clay crucible and poured on a stone slab. When cold it was pulverized and mixed with an equal weight of powdered fluorspar. This mixture, divided into portions of one ounce, was introduced into a French clay crucible, previously heated to redness. Eighty grains of sodium, cut into small pieces and freed from naphtha, being added to each portion, the crucible was covered, and reaction allowed to take place before adding another charge. After six ounces of the mixture had been added, the contents of the crucible was covered with fused chloride of sodium in powder, the cover replaced, and the heat carried to quiet fusion. After the flux became entirely fluid, the heat was continued for ten minutes. The crucible was then removed from the fire, and after cooling the metal was found as a button at the bottom.

Three crucibles, of the capacity of eight fluid ounces each, were used at a time in a furnace without artificial blast. Care is necessary not to urge the heat too high, otherwise the crucibles will not resist the action of the fluorspar flux. The French clay crucibles (Beaufay) were used on account of their greater freedom from iron and silica; they also resist the flux better than the Hessian, black lead, or iron crucibles.

The yield of manganese, under favorable circumstances, was about twenty per cent. of the chloride used.

Reduction was also tried by using fused chloride of sodium without fluorspar. The yield of metal was much less and differing in some of its properties from that obtained with the use of fluorspar. Manganate of soda was formed when sodium chloride alone was used as a flux.

Manganese thus obtained is very brittle, with a steel white fracture, so hard that a file will scarcely touch it. The edges of the fractures scratch and almost cut glass.

The metal retains the brightness of a fractured surface after prolonged exposure to the air, and appears not more disposed to oxidation than iron. It is entirely passive to magnetic attraction.

The specific gravity of the metal obtained when fluorspar was used was 7·072; when remelted under fused sodium chloride, the sp. gr. rose to 7·153.

The metal obtained without the use of fluorspar was less brittle, and had a different fracture; its sp. gr. was 7·231.

Authorities differ regarding the sp. gr. of manganese, ranging it from 6·85 to 8·013.

An examination of the metal obtained, using fluorspar as a flux, showed the absence of iron and the presence of calcium, demonstrating the reduction of some of the latter metal from the spar. This may account in a measure for the increased sp. gr. on remelting under sodium chloride, as also the greater sp. gr. of the metal when the spar was not used. As calcium has the sp. gr. of 1·57, a small amount alloyed with the manganese would sensibly affect its gravity.*

* Read at the meeting of the Chemical Section of the Franklin Institute, May 21, 1889. From the *Journal*.

ARTIFICIAL ARABIN.

PROFESSOR BALLO, of Buda-Pesth, has succeeded while attempting to reproduce the conditions under which the acids of the vegetable world are reduced by chlorophyl in synthesizing a carbohydrate of the empirical composition $C_6H_{10}O_5$, which possesses properties very closely resembling those of the arabin of gum arabic. It was assumed that the iron of chlorophyl is present in the ferrous state, and tartaric was the acid upon which operations were commenced. About equal quantities of tartaric acid and ferrous sulphate were dissolved in a minimum bulk of water, and the solution was warmed upon a water bath until a grayish-yellow precipitate began to separate, when the whole was evaporated until it solidified on cooling. The mass was extracted with alcohol, evaporated, neutralized with milk of lime, and filtered. During the evaporation of the filtrate it became viscid, and a sticky mass was left. On allowing the concentrated sirup to cool a calcium salt readily crystallized out, yielding on analysis numbers pointing to the formula $(C_6H_9O_5)_2Ca+9H_2O$. From this the free carbohydrate was readily obtained, and was purified by treating with alcohol and ether. This iso-arabin, as it is called, is an almost colorless sirup, readily mixing with water. It does not reduce Fehling's solution, but rotates the plane of polarization to the right. In addition to iso-arabin itself a small quantity of its hydrate, $C_6H_{12}O_6+H_2O$, is also formed by the action of ferrous sulphate upon tartaric acid, and separates out in crystals from the alcoholic washings of the crude iso-arabin. Natural arabin itself forms a similar hydrate, the precipitate formed by adding hydrochloric acid and alcohol to a solution of gum arabic, when dried at 100° C., possessing this composition.

Sp. gr. of iron, gray,	7·1
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